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A TEXT-BOOK OF SURGERY

BY

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TRANSLATED FROM THE FOURTH GERMAN EDITION BY

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REGIONAL SURGERY

WITH FOUR HUNDRED AND SEVENTEEN ILLUSTRATIONS

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PREFACE.

THE scientific side of German surgery has long been within the easy reach of English-speaking readers, in the translation of Billroth's Surgical Pathology, and more recently in that of Tillmanns's Principles of Surgery. The present translation is the first attempt that has been made to extend in like manner a knowledge of its practice. Tillmanns's work seems especially fitted for this purpose. Its author is actively engaged in surgical practice and teaching, and the three new editions of the work which have been called for within five years not only attest its popularity at home, but have also given occasion to make it exceptionally complete and accurate.

The formal separation of the general and special topics and the regional arrangement of the latter, facilitate reference, economize space, and aid the student and practitioner by bringing into close relations the various affections and injuries between which they will have to discriminate at the bedside. The list of subjects is so full that it includes even the great surgical rarities—whether disease, injury, or operation—and the descriptions are sufficiently complete to save the reader from the necessity of consulting other works to obtain the knowledge necessary to understand and to treat. The practitioner will find an especial advantage in the fulness and exactness with which the details of treatment are given.

It has seemed best, for several reasons, to make no comments upon or additions to the text in footnotes, but to present it to the American public exactly in the form given to it by its distinguished author.

BENJAMIN T. TILTON.

59 WEST THIRTY-SIXTH STREET, *May, 1897.*

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TILLMANNS' REGIONAL SURGERY.

FIRST SECTION.

SURGERY OF THE HEAD.

CHAPTER I.

INJURIES AND DISEASES OF THE SCALP.

Anatomical considerations.—*Injuries:* Scalp wounds (incised, punctured, contused, and gunshot wounds); contusions (hæmatoma). *Diseases* of the scalp; erysipelas, cellulitis, furuncle, carbuncle, eczema, ulcers, emphysema capitis, pneumatocele, aneurisms, tumours.

§ 1. **Anatomy of the Soft Parts and Bones of the Cranium.**—The cranium includes the entire hairy portion of the head as far as the nasal notch of the frontal bone in front and the root of the zygoma on the side. It is divided into (1) the frontal region, (2) the parietal region, (3) the occipital region, (4) laterally the temporal region, and (5) the base formed by the horizontal portion of the frontal bone, the ethmoid, the sphenoid, the temporal and the occipital. At the base of the skull lie the nerves, arteries, and veins of the brain, and here the cavity of the skull lies in close proximity to the frontal sinuses, the nasal fossæ, the orbital fossæ, the sphenoidal sinuses, the auditory canal, the cavities of the middle and internal ear, the temporo-maxillary articulation, the pharynx, and finally to the spinal canal.

The external coverings of the cranium, the injuries and diseases of which we shall first take up, consist of the skin, which is covered with hair as far as the forehead, and the aponeurosis, which is so firmly connected to the skin by means of stout connective tissue as to be more or less movable with it on the subjacent parts. In the frontal region the skin covers the frontal portion of the occipito-frontalis, in the temporal region the temporal muscle, and behind the occipital portion

of the occipito-frontalis. The two frontal portions form the anterior and the two occipital portions the posterior attachments of the aponeurosis, and the latter is to be looked upon as a tendinous expansion of this muscle. Both portions, together with their intervening aponeurosis, are sometimes designated as the epicranius muscle. According to Henle, the attollens, attrahens, and retrahens aurem are parts of the epicranius. Beneath the frontal portion lies the corrugator supercilii muscle, and upon its lower border the orbicularis palpebrarum. Wherever, in the frontal, temporal, and occipital regions the skin overlies muscle it is connected with the same by means of loose connective tissue, and hence movable upon it. For this reason collections of blood or pus can spread here very easily. The aponeurosis is attached to the periosteum by means of loose connective tissue made up of long fibres. Owing to the firm attachment of the aponeurosis to the skin, collections of blood or pus can not easily spread here, and hence they raise the skin in the form of circumscribed swellings. On account of this same close connection between the skin and aponeurosis it can be understood why in the case of flap wounds of the skin the aponeurosis is usually stripped up at the same time. On the other hand, extravasations of blood and collections of pus can easily spread beneath the aponeurosis by separating it from the subjacent periosteum.

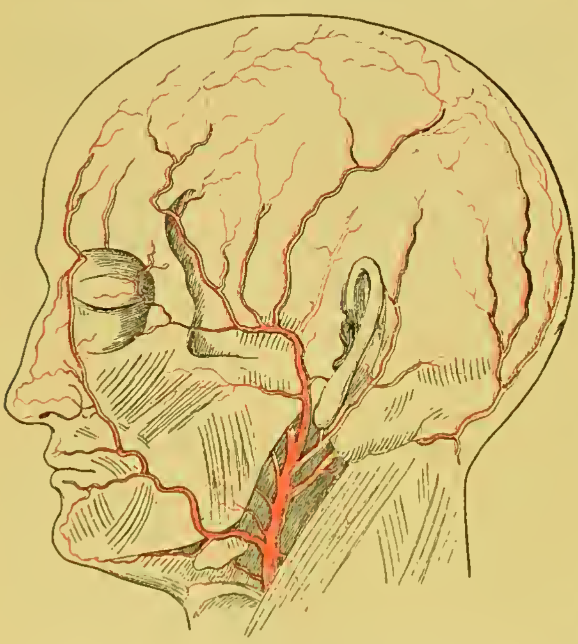
Fig. 1.—Arteries of the face and scalp.

The scalp is very richly supplied with blood-vessels (Fig. 1) which give rise in the case of wounds to very profuse hæmorrhage. For the same reason even very large flaps of skin in the case of scalp wounds remain well nourished, and easily heal in place by primary union under aseptic treatment, without necrosis.

The main arteries which supply the soft parts of the cranium are the anterior temporal and supra-orbital in the frontal region, the temporal in the temporal region, and the posterior auricular and occipital in the occipital region. They anastomose freely with one another, and are the favourite ones for the development of cirsoid aneurism. When it is desirable to operate upon the cranium with as little loss of blood as possible, it is a good plan to apply a tight elastic bandage about the frontal temporal, and occipital regions.

As the above-named arteries run toward the vertex of the skull, all incisions, especially on the lower parts of the cranium, should be made longitudinally.

The veins of the cranium unite to form three large trunks: the frontal the temporal, and the occipital. Their communication with the sinuses of the dura mater through the bones of the skull is of great practical importance. On account of this communication, inflammations of the external coverings of the skull can spread along the walls of the veins and involve the cranial cavity, and in the same way removal of blood or hæmorrhage from the veins of the scalp must necessarily decrease the amount of blood in the sinuses.

The nerves have essentially the same course as the vessels. The sensory nerves come from the fifth (frontal, supra-orbital, and auriculo-temporal branches), the motor nerves from the seventh (temporal branches) and the mixed nerves from the occipitalis major and minor.

The anterior lymph vessels run down the face along the facial vein to the submaxillary lymph glands. The posterior lymph vessels empty into the cervical lymphatic plexus, while the lateral ones in part pass down in front of the ear to the lymph glands of the parotid region, in part behind the ear to the lymph glands on the occiput and the mastoid process. As a result of the carrying off of infected lymph, from one of these regions the corresponding lymph glands become swollen.

The periosteum of the skull or pericranium is fairly thick, vascular, and closely attached to the surface of the bone, especially at the cranial sutures, where fibrous processes pass down between the bones. The intra- and extra-cranial arteries communicate through these sutures by means of small arteries called by Hyrtl rami perforantes, which are especially numerous in the region of the lambdoid and masto-occipital sutures. According to Hyrtl, they are never accompanied by veins. Moreover, the small arteries which pass from the periosteum through the bone communicate with those of the dura mater.

The bones of the skull consist of two tables and the intermediate diploë. We shall see later, under the subject of fractures, that either of the tables can be injured by itself. The inner table, on account of its great brittleness, is called lamina vitrea (" glass table "). The arteries of the diploë are branches both of the arteries within the skull, especially the middle meningeal, and of those of the external coverings of the skull. The veins of the diploë empty in part into the sinuses of the dura and in part into the external veins. The veins by means of which the venous vessels of the scalp communicate with the sinuses within the skull are called the emissaries of Santorini. The bony canals for the emissaries always run obliquely and sometimes even tortuously. Most emissaries in their passage through the bone are connected with the veins of the diploë.

The most important emissaries are, according to Hyrtl, the following:

1. The foramen cæcum, through which runs a communicating vein between the superior longitudinal sinus and the veins of the frontal sinuses and nasal fossæ.

2. The parietal foramina, situated near the posterior part of the sagittal suture, through which the parietal veins communicate with the superior longitudinal sinus.

3. The mastoid foramina are the largest, and transmit veins which form communications between the occipital and posterior auricular veins and the lateral sinuses. It was in the neighbourhood of these foramina that leeches were very commonly applied to draw off blood from the interior of the cranium.

4. The posterior condyloid foramina, which afford a communication between the large venous sinuses about the occipital foramen and the deep occipital and vertebral veins lying outside the skull.

The normal sutures on the vertex of the skull are so placed as to form a capital H, and those on the temporal region an X. The coronal suture forms the anterior, the lambdoid suture the posterior side, and the sagittal suture the connecting piece. The frontal suture, which persists until the fifth year, as the anatomical expression of the development of the frontal bone from two pieces, forms the continuation of the sagittal suture. Occasionally the frontal suture is permanent, and even when it disappears a trace of it often remains, according to Hyrtl, for life above the root of the nose.

It is of practical importance to note that sutures, especially abnormal ones, such as a frontal suture which has persisted, have sometimes been mistaken for fractures. The same is true of the supernumerary or Wormian bones. The latter are found especially in the region of the fontanelles, and arise from the independent development of different centres of ossification; they either consist, like the normal bones of the skull, of two tables with intervening diploë, or of one table, but seldom of the inner one alone. In hydrocephalus the number of Wormian bones is sometimes very much increased. Blumenbach counted one hundred and thirty supernumerary bones in the squamous suture in the case of a seventeen-year-old boy with hydrocephalus. These supernumerary bones are occasionally found in the cranial bones themselves. Hyrtl had in his possession a skull the left parietal bone of which contained eleven isolated bones.

The inner surface of the cranium is marked by depressions and eminences. The depressions are the following: (1) The so-called Impressiones digitatæ for the convolutions of the brain; (2) the grooves for the sinuses of the dura mater (Sulci venosi); (3) the Sulci arteriosi for the arteries of the dura mater, the largest being that for the middle meningeal, from which the very vascular bones of the skull

receive their blood supply; (4) the depressions for the Pacchionian bodies along the sagittal suture.

The eminences in part correspond to the depressions between the convolutions of the brain, and in part form projecting ridges (crista Galli, internal occipital protuberance).

For a description of the contents of the cranial cavity, see § 12.

§ 2. **Wounds of the Scalp.**—Scalp wounds are caused by sharp-cutting or puncturing implements, or by more blunt objects. The first include incised and stab wounds; the latter, lacerated, contused, and gunshot wounds.

Incised and stab wounds, as a rule, gape but little if ~~case~~ the skin alone is cut; but if the aponeurosis is divided, the edges of the wound become further separated. Horizontal wounds of the forehead and vertical ones of the temporal region gape the most. In the case of flap wounds the conditions for healing are favourable, because the flaps are well nourished, owing to the great vascularity of the soft parts. In fact, all wounds of the skull show a well-marked tendency to heal by primary union under aseptic treatment. On the hairy portion of the scalp the numerous hair follicles and hairs aid materially in the skinning over of the wound.

Punctured wounds often extend to the bone, and may have the form of long oblique canals. The deepest puncture wounds are those which extend from above downward behind the zygoma. They may be followed by very profuse hæmorrhage. Punctured wounds of the deep temporal artery are especially dangerous, as the hæmorrhage can sometimes not be stopped by direct ligation. In all cases of punctured wounds the possible presence of a foreign body in the wound must always be thought of, as the point of the instrument which inflicts the injury often breaks off and remains embedded in the soft parts or the bone. If the foreign body carries microbes with it, a dangerous cellulitis may result which, on the hairy portion of the head, is sometimes overlooked at first. As before remarked, a cellulitis spreads rapidly, especially beneath the aponeurosis, and raises the latter from the underlying periosteum over a large area in case an outlet for the pus is not provided for by means of prompt incisions.

Lacerated and contused wounds of the scalp are usually caused by blunt objects, by which the soft parts are pressed against the bone and thus divided, as happens, for example, from a fall upon some object which has an edge or a point, or from a blow. The wound thus made is either linear or more or less flap-shaped. In all cases of contused and lacerated wounds it is of the greatest importance for a favourable course of healing to see at the first dressing whether the skin has

been elevated over a large surface, and to make
pockets or undermined edges. If pockets are
carefully examined for the presence of foreign
cleansed, and perhaps split open. The edges o
of lacerated and contused wounds are sometime
smooth a
wounds, a
are more
often the
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mon in women, as their long hair is more easi

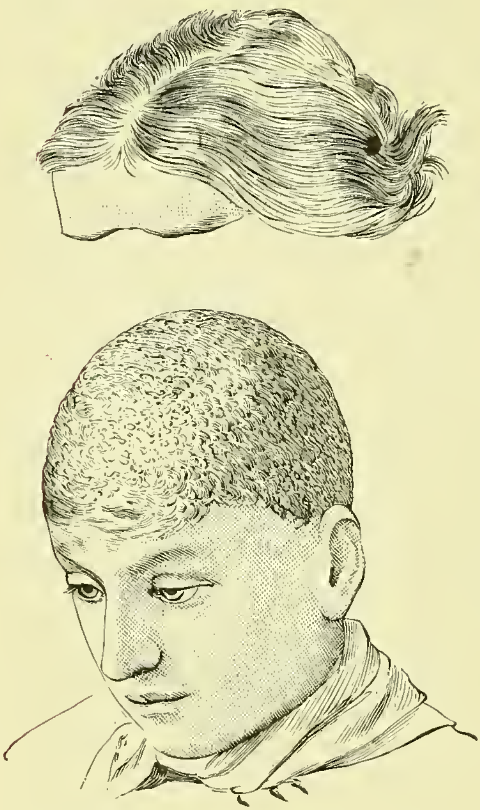


FIG. 2.—Complete avulsion of the scalp in a peasant girl, twenty-three years old, whose hair was caught in the wheel of a thrashing machine. Healing by skin-grafting (Bruns).

of the defeet was often very diffieult to bring about, and not quently death resulted from long-continued suppuration, mening erysipelas. Oeeasionally the healing process required years, but, to the improvements in the technique of skin-grafting brought by Thiersch, the prognosis even of complete avulsions of the sca beeome much more favourable, and the length of time requir healing is mueh shortened (see page 12).

Gunshot wounds of the scalp may be eaused, in the first pla small weapons, and are mostly grazing shots—i. e., shallow or furrows are made, and less often blind or eomplete canals with en and exit openings. Gunshot wounds of the soft parts are the most likely to come under treatment, sinee gunshot injuries of the of the skull usually cause immediate death. In the case of the plete gunshot eanals through the soft parts, with entrance an openings, the impinging ball raises a fold of skin and perforate at its base. Oceasionally the ball perforates the skin at one passes around the head without injuring the bone, and emerges other point on the opposite side, or is found here beneath the Gunshot wounds of this sort are made, as a rule, by spent balls, easily glance off from bone, tense fascia, etc.

Small shot, if discharged at short range, ean also cause eonsid laeeration of the skin. They usually heal into the scalp and bo the skull without any reaetion.

The wounds of the head caused by eannon balls, grenade shells are almost always fatal, as both bone and brain are u injured. It seldom happens that spent balls or pieces of shell give rise to lacerated and contused wounds, or even subcutaneous ries, without an open wound of the skin.

The prognosis of all wounds of the head, especially of contused ar wounds, depends less upon the extent of the injury than upon whethe able aseptic treatment is undertaken before the wound has become in Even very seriously contused wound flaps and edges regain their v very quickly under aseptic treatment, so that all symptoms may dis

ers its vitality entirely, the white surface of bone becomes reddened, granulation tissue makes its appearance, and the dreaded necrosis does not take place. When death occurs it usually results from a purulent meningitis caused by a spreading of the suppurative inflammation of the soft parts into the cranial cavity along the vessels, usually in the form of a phlebitis and periphlebitis, with or without septic inflammation of the diploë. I have seen two cases of death from comparatively small wounds of the scalp resulting from rapier cuts received in students' duels, and in both cases there was but a slight accumulation of pus, which, as the autopsy showed, had caused a suppurative phlebitis and periphlebitis of the veins of the bone with subsequent fatal meningitis. In all cases of suppuration beneath the aponeurosis the contents of the skull are more likely to be involved, for the reason that here the inflammatory exudate is under a certain amount of pressure.

Injuries to Nerves; Reflex Blindness following Injuries of the Scalp.—As a result of injury to the frontal branch of the ophthalmic nerve in the supra-orbital region, Dupuytren, Fischer, and others have observed reflex blindness take place. The blindness begins with an increasing irritation or neuralgia of the nerve at the point of injury, followed by reflex disturbances of vision, which may end in complete blindness on that side. Division of the supra-orbital nerve usually caused a disappearance of the neuralgia and blindness. Bergmann thinks that this reflex blindness is very rare. Disturbances of vision following injuries are usually due to injuries of the orbital fossa or the bulb of the eye in the form of fractures or fissures of the bones forming the orbit, extravasations of blood, or separation of the retina.

Neuralgia, Epilepsy, and Neuroses following Injuries of the Scalp.—Neuralgia of the fifth nerve in the frontal, temporal, and parietal regions not infrequently develops in cicatrices, especially after contused wounds. This neuralgia sometimes leads to epilepsy or other nervous diseases. By extirpation of the painful cicatrix it is often possible to cure the neuralgia or epilepsy permanently. I have seen several such cases. Among them was the case of a five-year-old boy who had a painful cicatrix in the left parietal region resulting from a fall. For nine months he had epileptic seizures, sometimes as often as ten or twenty times in twenty-four hours. After extirpation of the cicatrix the epileptic attacks stopped immediately and did not return.

Treatment of Wounds of the Scalp.—Every wound of the head, no matter how slight, should be treated with the strictest attention to the aseptic principles which will be found described at length in the Principles of Surgery, §§ 6, 20, 31–33, and 88.

The main rules for the antiseptic treatment of every scalp wound are as follows:

1. Careful disinfection of the wound and adjacent parts. Above all, the head should be carefully cleansed with soap and water, the hair shaved off over an area depending on the size of the wound, the shaved portion rubbed with ether, and finally the skin about the wound scrubbed with 1 in 1,000 bichloride or three-per-cent carbolic acid.

When necessary, the whole scalp should be shaved in order that a thorough examination may be made and the extent of the injury determined. If any bleeding takes place during these manipulations it should be arrested temporarily by pressure.

2. Hæmorrhage is checked according to the rules laid down in §§ 27–30 of the Principles of Surgery; if necessary, the bleeding point should be exposed by enlarging the wound. Permanent arrest of hæmorrhage is secured by tying the severed vessels, by suture, and by the application of a snug dressing. Dangerous hæmorrhages are only likely to occur in wounds of the soft parts about the temporal region in the area supplied by the deep temporal and occipital arteries. Death has occurred several times as a result of hæmorrhage from the deep temporal artery, and in other cases the external carotid had to be tied because it was impossible to tie the anterior and posterior branches of the deep temporal at its origin from the internal maxillary behind and below the zygoma. The superficial temporal artery can be most easily tied at the point where it crosses the zygoma one half to one centimetre in front of the tragus, at which place it is covered only by the skin and the aponeurosis of the scalp, which envelops it in a sort of sheath.

The external carotid has also been ligated several times for hæmorrhage from the occipital artery. But here arrest of hæmorrhage is easily accomplished by ligature or suture at the point of injury. If one should desire to tie the trunk of the occipital artery it can be exposed at the point where it emerges between the upper points of insertion of the trapezius and splenius muscles (see also § 90, Ligation of the Arteries of the Neck).

Bleeding in the wound, as in all injuries, is usually stopped by ligatures or sutures. If necessary, the wound is enlarged in order to expose the bleeding point. In case a large vessel is wounded, the proximal and distal ends should be tied, in order to prevent secondary hæmorrhage from the distal end after the collateral circulation has become established. For the same reason branches of large vessels which come off near the point of injury should be carefully tied. This double ligation of vessels is scarcely ever necessary on the head, except, perhaps, for punctured wounds of the temporal and occipital arteries.

Bleeding from the vessels in the skin is checked by suture of the wound and the pressure of the dressings. For tying vessels, aseptic catgut or silk should be used. For a description of the preparation of a good aseptic catgut see page 88 of the Principles of Surgery.

3. Careful examination and cleansing of the wound, especially of

the pockets and undermined edges, and removal of foreign bodies, such as hairs, dirt of various kinds, pieces of glass, wood, metal, etc. Blood clots should also be removed, as they decompose easily and interfere with the process of healing. As a result of the decomposition of blood clots in an apparently trivial wound, secondary phlebitis of the veins of the cranial bones and fatal meningitis may ensue. In the temporal region suppuration may easily spread toward the zygomatic fossa and the base of the skull, and cause death from meningitis or œdema of the glottis. The most satisfactory examination of the wound is made with the eye and finger; the probe, which must, of course, always be aseptic, is, as a rule, less useful.

Badly contused and necrotic edges of a wound should be cut away, but it must be remembered that the scalp is very vascular, and portions of skin which seem in danger often regain their vitality under aseptic treatment. Pockets and undermined edges should be drained through counter openings in the skin, or by means of short drainage-tubes placed in the most dependent part of the wound. The drainage-tubes are secured in position by means of a suture or a safety pin. In punctured wounds particular search should be made for foreign bodies and injuries of the deeply lying arteries, especially the deep temporal artery, in case of punctured wounds in the temporal region made from above downward.

Fig. 3.—Aseptic protective dressing for the head, neck, and chest.

4. For suture of the wound aseptic catgut or fine aseptic silk is used. It is often advisable to sew up the wound only partially or not at all, as, for example, in contused wounds. In suitable cases a wound which was not sewed up at first may be closed later by means of secondary sutures.

5. The following antiseptic or aseptic dressing is then applied: The wound is covered with gauze which has been sterilized by steam at a temperature of 100° C., or with moist wrung-out bichloride gauze. Over this is placed sterilized cotton or other soft material, and the whole is secured in position by a gauze bandage which exerts press-

ure (see Figs. 3, 4, and 5). If in private practice roller bandages are not to be had, pieces of cloth cut into the proper shape may be used (see Figs. 6 to 9). "Protective" should not be placed over the wound,

Fig. 4.—Aseptic dressing for the head.

Fig. 5.—Mitra hippocratis.

Fig. 6.—Capitium parvum.

Fig. 7.—Capitium magnum.

as it prevents the wound from remaining dry. For the same reason rubber tissue should not be placed over the dressings. Aseptic powders, such as iodoform, oxide of zinc, bismuth, etc., are not used as much as formerly for dusting over the wound.

If the wound runs a normal course, even though it be a very extensive one, fever and pain are both absent. In the case of large wounds it is a good plan to change the dressings frequently, beginning

a *b*

Fig. 8.—Triangular bandages for the head.

Fig. 9.—Capitium quadrangulare.

with the second day. The drainage-tubes and some of the stitches should be removed as soon as possible—perhaps the next day or at the end of two days. Very often all dressings may be discontinued in a few days. A wound which has healed by primary union may be painted with simple collodion or iodoform collodion, or a mixture of bismuth and bichloride of mercury. The latter dries in the form of an aseptic crust. Even very extensive wounds, if treated aseptically, have healed by primary union at the end of six to eight days.

Contused or large flap wounds require, as a rule, a somewhat longer time.

As regards extensive avulsions of the scalp, here, too, very excellent results are obtained by the use of strict asepsis, in case the scalp is joined to the intact soft parts by a sufficiently broad bridge of tissue. After shaving off the hair the entire exposed portion of the vault of the skull and the covering of soft parts should be disinfected with 1-in-1,000 bichloride or three-per-cent carbolic acid. Numerous short drainage-tubes should be placed in the most dependent parts of the wound, and the edges of the skin brought together by sutures, short drainage-tubes being inserted here and there in the line of suture. In the parietal region as well one must allow the discharge from the wound to escape by means of drainage-tubes or counter openings in the skin. If the scalp which has become separated is not drawn back again over the surface of the bone, it becomes more and more retracted downward, as in a characteristic case described by Hilton.

If, however, the scalp is completely torn away one can, as Gussenbauer recommends, transplant pieces of the same on to the wound. If this does not succeed, skin-grafting should be resorted to in order to bring about cicatrization of the losses of substance, prevent cicatricial contraction of the skin, and lessen the disfigurement as much as possible. Before the technique of skin-grafting became as well developed as at present, the length of time required for complete healing was sometimes very considerable. In a severe case of Gussenbauer's, in which the entire scalp was torn off by machinery, twenty months were required for a complete healing, as the cicatrices kept breaking open. In this case Gussenbauer grafted three hundred and forty pieces of skin, two hundred and seventy of which healed in place. In another case of Gussenbauer's, in which likewise the entire scalp of a sixteen-year-old girl was torn off by a rotating spindle, death resulted eleven months and twenty-three days after the injury. At present such complete avulsions of the scalp are more quickly and completely healed over by means of Thiersch's method of skin-grafting. In one case of removal of almost the entire scalp I brought about a favourable result in five weeks by means of this method, although in several places the bone was bared of its periosteum. For the technique of Thiersch's method of skin-grafting see the Principles of Surgery, page 141.

In suitable cases one may cover the defect with skin flaps, as recommended by Volkmann and Messner, in order to obtain a scalp that is partially covered with hair. Four flaps are cut, as shown in Fig. 10 *a*, which are laid over the defect (Fig. 10 *b*), and the different angles brought together as far as possible by sutures.

Gunshot wounds of the scalp should be treated in general like contused wounds; complete canals should, if necessary, be split open, and badly contused and necrotic edges removed. Ice was at one time very commonly used in the treatment of wounds of the head, but since the introduction of antiseptic surgery the use of cold for fresh wounds that have been treated aseptically is no longer necessary. It is only in the case of inflamed and suppurating—i. e., infected—wounds

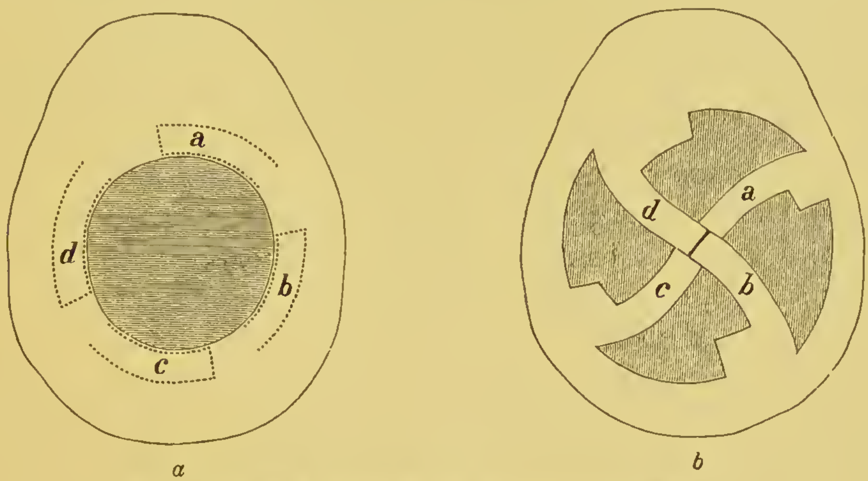


Fig. 10.—Plastic operation for defects of the scalp.

that the use of cold as an antiphlogistic and sedative remedy is to be recommended, and it is then best employed in the form of an ice bag or Leiter's coil.

Leiter's "temperature regulator" consists of a coil of flexible tinned lead pipes, which can adapt itself to any part of the body.

The ends of this system of pipes are connected with rubber tubing for conducting and carrying away the water which flows through the pipes. In this way cold or heat can be made use of in any region of the body. These regulators can also be very easily made at a moment's notice out of large, thick rubber tubing.

The same rules of antisepsis or asepsis hold for already infected—i. e., inflamed and suppurating—wounds. It is here necessary to provide for the escape of the serous secretion or pus by means of incisions and drainage. Spreading suppuration must be combated by multiple incisions, and often requires that the entire scalp be shaved for the sake of a more thorough examination. It is only by the employment of numerous and sufficiently free incisions that one can prevent suppuration from spreading to the diploë of the skull and the meninges. In case the bone becomes infiltrated with pus and changes its colour to a characteristic greenish yellow, it is best to chisel away the affected bone in its entire thickness in order to save the patient

from a fatal meningitis, sinus phlebitis, and pyæmia. Inflamed and suppurating wounds of the head should be dressed frequently and retention of pus carefully guarded against.

Wet dressings of bichloride or carbolic acid are often to be recommended for suppurating wounds, but pressure should, of course, be avoided. For the pain ice may be used with advantage.

For the treatment of the bone complications, such as necrosis, see §§ 6–11, Injuries of the Bones of the Skull.

§ 3. **Subcutaneous Injuries of the Scalp.**—The subcutaneous injuries of the scalp, including the rupture of vessels and contusions without open wounds, result, as a rule, from contact with blunt objects. These contusions of the soft tissues are characterized by the presence of diffuse or circumscribed effusions of blood. The latter form fluctuating tumours, varying in size, and are called hæmatomata. According to the situation of a hæmatoma it may be spoken of as subcutaneous, subaponeurotic, or subperiosteal, but one may be a transition form or a combination of all three.

1. The subcutaneous variety of hæmatoma is most commonly seen in children in the frontal, parietal, and occipital regions, and is usually caused by a blow or a fall. The skin, which is usually uninjured, is raised from the deeper parts by the extravasation, and in a few hours changes to a bluish, dark blue, and later a greenish or yellowish colour, as a result of the diffusion of the colouring matter of the blood. These subcutaneous hæmatomata remain small in those places where the skin is closely joined to the aponeurosis by dense connective tissue, and feel harder than the subaponeurotic variety. Subcutaneous hæmatomata hardly require any treatment other than the employment of pressure to check the hæmorrhage under the skin and aid in the absorption of the blood.

2. Subaponeurotic hæmatomata—i. e., those situated under the aponeurosis of the scalp—can spread for a great distance in the loose connective tissue between the latter and the periosteum. Very extensive effusions are particularly likely to result when large veins or arteries have been torn. The increase in the size of the hæmatoma may be rapid or gradual. In the case of an arterial hæmatoma pulsation is not infrequently observed, which should, however, not be confused with the brain pulsation found in compound fractures. Very often, as a result of an infiltration of the connective tissue with blood, one can feel a hard elevated rim about the circumscribed extravasation of blood which may make one think of a depressed fracture. If, however, the hæmatoma is pressed and kneaded away, the smooth, non-depressed bone can be felt deep down and on a level with the surrounding parts.

3. Subperiosteal hæmatomata resulting from a forcible separation of the periosteum from the bone, with rupture of the intervening vessels, are most common in children, in whom the bones are in a more active process of growth. In case large vessels are ruptured, the periosteum is lifted from the bone over a considerable area. The cephalhæmatoma found on the scalp of infants belongs to the subperiosteal variety. It is only seldom situated between the aponeurosis and the periosteum. It is, on the whole, not common, and is caused by pressure on the coverings of the skull with a rupture of vessels. As a result of contusion of the soft parts of the skull from contact with the bony prominences of the pelvis, including the promontory, rim of the pubes, and the symphysis, or from pressure of the forceps, the head of the infant may receive corresponding pressure marks. These pressure marks vary very much in degree from a temporary hyperæmia to a serious crushing, followed by necrosis and suppuration. Sometimes death results from diffuse suppuration and meningitis.

The above-described cephalhæmatoma should not be confused with the œdematous swelling of the infant's scalp, known as caput succedaneum, which results from the pressure of the pelvic bones and the encircling os uteri. This caput succedaneum, which may also be combined with hæmorrhage, is formed on that part of the infant's head which presents and is thus not subjected to the pressure of the os or the pelvic bones. It disappears very quickly after birth without treatment.

Injuries to the infant's head are also said to occur *in utero*, so that children are born while they are still more or less recent or already healed up. Bergmann, however, rightly insists that such injuries to the fœtus are much more commonly affirmed than proved.

The most favourable and the ordinary outcome of extravasations of blood is complete absorption ; even very large extravasations disappear, as a rule, in this way. Large, circumscribed hæmatomata are gradually replaced by new connective tissue. In the case of contusions of the periosteum a temporary or permanent thickening of the bone takes place at that point. This growth of bone is particularly well marked in the cephalhæmatoma of infants. Here a wall of new bone can be felt after some time around the extravasation, and isolated plates of bone resembling the Wormian bones are sometimes formed on the inner surface of the elevated periosteum. These thickenings of the bone and soft parts are sometimes the seat of a neuralgia, and may lead to reflex epilepsy. Occasionally in the region of extravasation a cyst develops—i. e., a cavity surrounded by a connective-tissue capsule and filled with a yellowish-red fluid, such as is often seen in cerebral hæmorrhages or hæmorrhages within the thyroid gland or in tumours. Sometimes blood cysts of this sort communicate through an emissary with a sinus

of the dura mater, and are then of great importance in case operative procedures are contemplated.

Subcutaneous rupture of vessels may also give rise to an angeioma, an aneurism, and particularly an arterio-venous aneurism.

Suppuration of subcutaneous extravasations of blood which is recognised by pain, hyperæmia, and fever, is only possible when pyogenic organisms gain access to the hæmatoma through a wound in the skin, or by means of the blood or lymph channels, or, finally, when the crushed tissues become gangrenous. In this way diffuse suppuration may result, ending in a fatal meningitis. Even very insignificant wounds of the skin may for this reason become dangerous, if at the time of injury the pus microbes are, as it were, pressed into the wound. Erysipelas may likewise result from very slight injuries to the cutaneous surface, and lead secondarily to suppuration of the hæmatoma.

Necrosis of the soft parts can result from a severe contusion, but gangrene of the skin from pressure of the extravasated blood is rare, as the skin on the scalp is very vascular, and hence well nourished.

The treatment of subcutaneous injuries of the scalp is directed first of all toward as prompt an absorption of the extravasated blood as possible; this is best accomplished by massage and by the use of pressure, such as can be made, for example, by rubber bandages. This form of treatment is much preferable to that with ice. In mild cases treatment is unnecessary, as the hæmorrhage stops of its own accord and absorption takes place spontaneously. For extensive hæmatomata dressings of cotton, sterilized compresses, and gauze bandages are to be recommended. In suitable cases the fascia nodosa (Fig. 11) and capistrum duplex (Fig. 12), may be used in putting on a compressive dressing. When it is desirable to produce pressure at one point on the scalp a webbed elastic bandage is of use.

Fig. 11.—Fascia nodosa.

Fig. 12.—Capistrum duplex.

If, in spite of pressure, the hæmatoma increases in size, as may be the case when a large vessel has been ruptured, one should make a sufficiently long incision, retract the edges of the wound with sharp hooks, remove the blood clots, and secure the bleeding vessel by a ligature or a suture; finally, the wound, after being partially or completely closed by sutures, should be covered by an aseptic compressive dressing. In case of suppuration liberal incisions should be made, and, if neces-

sary, drainage employed. Wounds and abrasions of the skin over a hæmatoma, no matter how trivial, should be treated aseptically in order to prevent secondary suppuration of the effusion.

If the absorption of a hæmatoma is delayed, one can shorten the healing process by making a puncture or small incision with a sharp-pointed knife, letting the blood run out, or gently pressing out the blood clots, and then applying for four or five days a dressing that exerts pressure.

§ 4. **Diseases of the Scalp.**—Among the diseases of the scalp one of the most important is erysipelas, which starts from wounds which have not been treated aseptically, from suppurative processes including those in the frontal sinuses and nasal fossæ, from an eczema, and even from slight abrasions of the skin. Genuine erysipelas begins, without exception, in some break in the continuity of the skin, which is often so trivial as to be overlooked. Through this break in continuity the streptococcus of erysipelas makes its way into the tissues, especially the small lymph channels, and produces a spreading inflammation of the skin and subcutaneous cellular tissue, which only rarely goes on to suppuration. The so-called "idiopathic erysipelas," according to my opinion, does not exist, although an erysipelas may have a metastatic origin, as in pyæmia. The so-called "habitual erysipelas"—i. e., an erysipelas of the head, which returns at more or less regular intervals—usually begins on the face, and frequently owes its origin to a chronic nasal catarrh with ulcerations. For a more detailed account of the ætiology, course, and treatment of erysipelas see § 71 of the Principles of Surgery. The following brief description will suffice here:

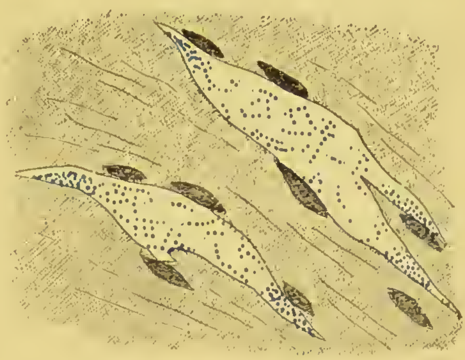


Fig. 13.—Streptococci of erysipelas in two lymph vessels of the skin. × 700.

The spread of erysipelas on the head is often checked by the insertions of the fascia, especially at the back of the neck. Vesicles are rare on the scalp, but more common in the region of the forehead and the ears. The swelling is especially marked on the last-named parts and the eyelids.

In regard to the symptoms of erysipelas of the head, it should be noted that it is often complicated by cerebral manifestations, such as stupor, and a delirium which is not infrequently maniacal. These brain symptoms are due partly to the direct cerebral irritation from inflammation of the external soft parts, and partly to the fever. Some-

times marked meningeal symptoms are present, such as vomiting, delirium, stupor, convulsions, and paralysis. Occasionally an erysipelas becomes complicated by a suppurative cellulitis, which may prove fatal from suppurative inflammation of the diploë, meningitis, thrombosis of the dural sinuses, and pyæmia. In such cases the inflammation spreads to the cranial cavity along the vessels which pass through the bone, especially the emissaries. Numerous localized abscesses sometimes develop in the soft parts, with corresponding death of tissue, as in the aponeurosis and the eyelids.

The involvement of the cellular tissue of the orbit by an erysipelas is a matter of great prognostic importance, especially when it is complicated with phlebitis and suppuration, since a fatal thrombosis of the sinuses and meningitis can easily take place, and the eye itself be damaged. Disturbances of vision as well as of hearing not infrequently follow erysipelas of the head. Occasionally an erysipelas involves the mouth, throat, and larynx, and death may result from œdema of the glottis if tracheotomy is not performed early enough. The throat is not infrequently the seat of complicating diphtheritic changes.

The wound itself is but slightly affected by the erysipelas, and primary union is usually not delayed. In other cases the wound heals over only on the surface, while deeper down there is retained serum and pus. Granulating wounds sometimes become covered with a croupous or diphtheritic membrane, or in rare cases hospital gangrene may develop, if the rules of antisepsis have been too much neglected.

As a rule, the hair drops out after an attack of erysipelas, but it usually grows again as thick as before.

It is a matter of great interest to note that erysipelas has a favourable influence on new growths, especially those of lupus and syphilis, with or without ulceration, and upon true tumours, such as sarcoma and carcinoma (so-called curative erysipelas). These formations have been seen to disappear permanently, and ulcers of long standing and chronic skin diseases which have resisted every form of treatment improve, and even heal up after an erysipelas has passed over them. W. Busch was probably the first to make the observation that sarcomata of the face and lympho-sarcomata of the neck rapidly underwent a fatty degeneration, and in this way disappeared by absorption.

More recently Janicke and Neisser have observed that the cancer cells are destroyed by the erysipelas germs, and it is thus conceivable that a carcinoma may be cured by erysipelas. This fact in regard to the therapeutic action of erysipelas on pathological products has been made use of in the form of inoculations of erysipelas for causing the

disappearance of inoperable tumours. Before, however, an experiment of this sort is attempted one should take into consideration that one can not promise a favourable result from the inoculated erysipelas, and that, on the contrary, it may prove fatal.

The prognosis of erysipelas of the head is very much influenced by the close proximity of the cranial cavity and the brain, to which the inflammation can so easily spread, particularly when complicated by suppuration, phlebitis, or gangrene. Hence the prognosis of erysipelas in this region is on the whole less favourable than in other parts of the body. For other complications of erysipelas see § 71 of the Principles of Surgery.

The treatment of erysipelas of the head follows the rules laid down in the Principles of Surgery. Above all, prophylaxis is very necessary—i. e., one should treat even the smallest abrasion of the skin on the head according to antiseptic principles. In order to see the extent and watch the spread of the erysipelas, it is a good plan to shave the scalp over a sufficiently large area. Besides the different methods of treatment described in the Principles of Surgery, that by multiple scarifications of the skin, followed by the application of protective gauze dressings soaked in three-per-cent carbolic acid or 1-in-1,000 bichloride, deserves special mention.

Wölfer has obtained good results by the use of strips of adhesive plaster, half an inch in breadth, applied along the edges of the erysipelas.

Cellulitis of the Scalp, like erysipelas, may start from an insignificant break in the continuity of the skin which has not received aseptic treatment, and is not infrequently combined with erysipelas. There are, in the main, two varieties which differ both anatomically and clinically—viz., the superficial or subcutaneous, and the deeper subaponeurotic and subperiosteal. It is the latter forms which are especially dangerous, and can cause very marked disturbances. The aponeurosis not infrequently sloughs away in large pieces, and the periosteum, when involved in the inflammation, may, on account of the suppuration underneath, be lifted from the bone and become necrotic. This does not, however, necessarily involve a necrosis of the bone, as the latter usually receives sufficient nourishment from the dura. If necrosis of the bone does occur it is for the same reason usually only superficial. The cases which give the worst prognosis are those in which there is a diffuse sloughing of tissue, with the formation of large amounts of foul pus, and sometimes of gas. As in erysipelas, the great danger lies in the involvement of the cranial cavity, in which case death, preceded by coma and convulsions, usually occurs from

suppurative meningitis or sinus thrombosis. In other cases death takes place from septicæmia or pyæmia. An unfavourable outcome of a diffuse cellulitis is especially to be feared in those cases which are not recognised at an early period.

The diagnosis of the deep varieties of cellulitis is sometimes difficult for the inexperienced, because fluctuation and hyperæmia of the skin are often not sufficiently well marked. Moreover, on account of the hair, any inflammation of the scalp is difficult to recognise. Hence, in order to make a thorough examination and make sure of the extent of the inflammation, the hair should be shaved off, which is also a necessary preliminary to an incision.

The treatment of a cellulitis of the scalp should be carried out according to the general rules for inflammation and suppuration. For the sake of prophylaxis, even the smallest wound on the head should be treated antiseptically. If the cellulitis is in its first stage, and there is redness, swelling, and tenderness on pressure, the region should be laid open by incisions, even though fluctuation can not be made out. By early incisions, before pus or fluctuation are present, a beginning cellulitis may often be cut short, so that it does not go on to suppuration. In general, long incisions are preferable to short ones, and one should not be too sparing in their number; it is better to incise too freely rather than too little. After the incisions have been made a wet antiseptic gauze dressing should be applied, and possibly, an ice bag or cap, or the cooling apparatus of Leiter's, mentioned above. If marked suppuration is already present, short drainage-tubes should be inserted in the most dependent parts of the wound. In case of necrosis of the aponeurosis it is especially necessary to make long and numerous incisions in order to be able to remove the shreds of gangrenous tissue. Necrosis of bone is to be treated according to general principles (see Principles of Surgery, § 106). It should, however, be remembered that although the bone may appear to be necrotic, it often becomes restored to life again. In order to bring about a more rapid cicatrization of the granulations after extensive gangrenous destruction of the soft parts, skin-grafting may be resorted to.

Furuncle—i. e., an acute inflammation of the glands and follicles of the skin, caused by the *Staphylococcus pyogenes aureus* and *albus*—is not very common on the scalp, but is more frequent on the back of the neck and the border line of the hair. This is also the favourite place for a carbuncle, by which is meant a number of furuncles lying close together. The extent of the surface covered by a carbuncle is sometimes very considerable. A furuncle usually begins as a small pustule (acne) about the size of the head of a pin, which enlarges and forms a very painful nodule about the size of

a pea or a bean. Furuncles occasionally appear in great numbers in different parts of the body. The carbuncle has a more marked tendency to enlarge toward the periphery than the furuncle, and not infrequently spreads from the back of the neck to the scalp, where it may be the cause of a secondary fatal meningitis and sinus thrombosis. The amount of necrosis of the skin and subjacent soft parts, especially at the back of the neck, is sometimes very great. When a carbuncle appears in the course of diabetes the gangrenous destruction is often very extensive, and death not infrequently takes place from septicæmia or pyæmia. It is an interesting fact that even in healthy individuals sugar sometimes appears in the urine during the course of a furunculosis, and disappears again after the inflammation has come to an end.

For a description of malignant pustule (anthrax) see Principles of Surgery, § 77.

The treatment of a furuncle and carbuncle consists in a prompt incision, under cocaine or the ether spray, in order to lessen the painful tension, and provide an escape for the pus. The sooner one makes an incision the better, since in this way the further development of the furuncle and carbuncle can be checked. In the case of large furuncles and in carbuncles a cruciform incision is the best. In the latter especially, when there is a secondary cellulitis, the number of incisions is governed by the extent of the inflammation. If there is plainly necrosis present, the gangrenous, purulent, and softened tissues should be removed with a sharp spoon or scissors and thumb forceps, and the focus disinfected with 1-in-1,000 bichloride. Salve dressings, such as boric-acid ointment, vaseline, or lanolin, combined perhaps with iodoform, bismuth, and oxide of zinc, are to be preferred to dry dressings. For the purpose of softening inflamed and infiltrated areas warm poultices can be used, but here, also, an incision is the best means of hastening the healing process. In the further course of a carbuncle one must be on the lookout for any burrowing or retention of pus, and treat them by prompt incisions. In the case of old or weak individuals their strength should be kept up by wine, nourishing food, etc.

Eczema of the scalp, especially of the hairy portion, is common in children who are not kept clean. In extensive eczema the best treatment consists in shaving the head, softening the crusts with oil, applying unguentum diachylon in a thick layer, or zinc oxide, or amylum and zinc oxide in powdered form, and covering the scalp with lint or cotton, which can be kept in place by bandages, as in Figs. 4–8, or by a nightcap. After a few days the parts should be sprinkled with amylum or oxide of zinc and amylum (1 to 5, or equal parts), and kept as dry as possible.

Ulcers of the scalp are most commonly tubercular (lupus), syphilitic, or carcinomatous. The tubercular ulcer of the scalp, the so-called lupus, usually results from the spreading of a similar process from the face, for a detailed description of which see § 27 (The Face). Primary syphilitic disease of the scalp, which we shall take up in connection with syphilitic disease of the bones of the skull (§ 11), is more common. We shall then discuss the differential diagnosis between lupoid (tubercular) and syphilitic ulcers. In regard to carcinomatous ulcers of the skull see page 30 (Tumours of the Scalp).

Emphysema of the scalp—i. e., a collection of air most commonly between the periosteum and the aponeurosis—is sometimes a temporary complication of fractures of the skull through the nasal, ethmoid, frontal, or temporal bones, which allow air to pass from the nasal fossæ, the ethmoid cells, the frontal sinuses, and the mastoid cells, into and beneath the scalp. Moreover, a too energetic use of the air-insufflator during catheterization of the Eustachian tube has been known to cause emphysema in the region of the mastoid process. Heineke mentions a case described by Fabricius Hildanus in which the parents of a young child caused an emphysema of the scalp by blowing air into a small wound, and afterward exhibited it for money. The traumatic emphysema following the above-mentioned varieties of fracture of the skull is usually not extensive.

Any emphysema of the external surface of the body can always be recognised by the presence of a characteristic soft, painless swelling which gives a sensation of crepitation beneath the finger.

It is unnecessary to treat a traumatic emphysema of the scalp, as it usually disappears spontaneously. If there is a small external wound present, it may be enlarged sufficiently to help the air to escape.

Pneumatocele Capitis.—In other cases there is a chronic or more or less permanent collection of air under the scalp, to which the name pneumatocele capitis has been given. There is here a collection of air between the periosteum and bone which comes from the mastoid cells, and less frequently from the frontal sinuses or the antrum of Highmore. Heineke states that there are ten cases in literature of pneumatocele which communicated with the mastoid process. In recent years Sonnenburg, Bergmann, Rose, and others have observed cases of pneumatocele. Helly collected seventeen cases affecting the occipital region, and nine cases in which there was a communication with the frontal sinuses. Wernher has reported a particularly interesting case of occipital or supramastoid pneumatocele.

FIG. 14.—Pneumatocele cranii (supramastoidea) in a weaver twenty years of age, due to a congenital defect of the bony covering of the mastoid cells and caused by a violent sneeze.

This case (see Fig. 14) was that of a twenty-year-old weakly man who four years previously, after sneezing violently, noticed a swelling the size of a pigeon's egg behind the right ear over the upper part of the mastoid process; this swelling could be easily made to disappear on pressure, but re-

turned again upon deep expiration. The swelling then gradually began to grow larger, until it finally involved almost the entire scalp. It was soft, painless, tympanitic on percussion, and became gradually smaller on pressure, whereby a blowing noise could be heard in the middle ear. It could not, as at first, be made to disappear entirely on pressure. A feeling of soft crepitation could not be made out on palpation. During a deep expiration with the mouth closed, the tumour gradually grew larger and more tense.

Pneumatocele of the head, communicating with the mastoid cells, is caused by congenital or acquired defects in the external bony covering of the cells, through which at every increase of pressure in the tympanic cavity, as in sneezing, coughing, or snoring, air is driven beneath the periosteum of the temporal bone. At first the elastic painless swelling thus formed over the mastoid process can be made to disappear by pressure, but in the course of years it can gradually involve more and more of the occipital and parietal regions, while its extension toward the front and back of the neck is checked by the insertions of the cervical muscles. The disturbances caused by these supra-mastoid pneumatoceles are usually slight. The defects in the bony covering of the mastoid cells are either the result of the persistence of the squamo-mastoid fissure, or of congenital gaps in the skull. Sometimes, instead of gaps, there are numerous large openings for vessels in and above the mastoid process. Through these openings, which communicate with the mastoid cells, air can pass from the tympanic cavity and the pharynx beneath the skin of the scalp, or under the periosteum. Acquired defects may be the result of injuries or inflammatory processes with caries and necrosis.

The best treatment of a pneumatocele which communicates with the mastoid process is by incision under antiseptic precautions, combined with pressure on the tumour at regular intervals. Wernher brought about a cure in his case by puncture, followed by the injection of tincture of iodine after the swelling had been decreased in size by the use of pressure applied for a long time. A small quantity of tincture of iodine was injected at four different times into different parts of the swelling. The resulting inflammatory reaction was only slight.

Heineke has found in literature five cases of pneumatocele communicating with the frontal sinuses (pneumatocele syncipitalis), and Helly nine cases. One individual was twelve years old. This form of pneumatocele can hardly come under observation at an earlier period, since the frontal sinuses are not developed until the end of the tenth year. In the majority of cases the swelling was small, and occupied the middle of the frontal region or the entire frontal region; but in a case

reported by Jarjavay it extended from the forehead to the occipital bone. The cause is to be sought for in defects in the bony walls of the frontal sinuses due to injuries and inflammatory processes, especially syphilis. Fig. 15 represents a case seen by Mason Warren, in which a swelling filled with air made its appearance in the region of the frontal sinuses after necrosis of the walls of the sinuses due to traumatic suppuration. In rare cases there are congenital defects of the anterior wall, or the air may come out through abnormally large openings intended for the passage of vessels. The diagnosis is probably easy to make in all cases.

FIG. 15.—Pneumatocele capitis in a man forty-five years of age, following necrosis of the walls of the frontal sinuses from traumatic suppuration.

The treatment of pneumatoceles which communicate with the frontal sinuses consists, according to Heineke and Helly, in puncture, compression, or incision. In three cases puncture was unsuccessful. The treatment by compression can only be successful when there is no suppuration present. Incision, followed by packing, is the best form of treatment.

Large fissures or gaps in the bone could be closed by periosteal or bone flaps, or transplanted bone. The case seen by Wölfler and Helly was cured by erysipelas. On account of the inflammation in the skin, solid union took place between the skin and bone.

The formation of gas in the course of a septic cellulitis of the scalp has already been spoken of on page 19.

Aneurisms of the Scalp—i. e., cylindrical, spindle-shaped, or sacculated dilatations of arteries—are most common in the region of the temporal artery after injury of the same by a cut, stab, or contusion. These traumatic aneurisms result from a gradual yielding of the thrombus formed on the inner wall of the vessel at the seat of injury, and of the surrounding loose connective tissue from the impulse of the blood wave, until finally a sac is formed, the wall of which consists of the outermost layers of the thrombus, the surrounding soft parts, and newly formed connective tissue. In the case of non-traumatic or true aneurisms, the artery gradually increases in circumference as a result of chronic endarteritis, which weakens the walls of the vessel to such an extent that they gradually yield to the blood-pressure. These

aneurisms of the scalp vary considerably in size; they have been seen as large as a hen's egg. As they increase in size the bone may become more and more eroded, and the skin may likewise become perforated.

In case the artery and corresponding vein are wounded simultaneously, an arterio-venous aneurism may result—i. e., a communication between the artery and vein is established, in some cases through an intervening sac. Owing to a communication between the artery and vein, marked disturbances in the circulation result with pulsating dilatations of the arterial and venous branches (Fig. 16). Almost all arterio-venous aneurisms result from injuries. Bramann states that among one hundred and fifty-nine cases there were only nine which began spontaneously. When spontaneous, there is at first a gradual dilatation of the artery from chronic endarteritis; the dilated sac then becomes adherent to the vein, and finally the aneurism breaks through either into the open or already obliterated vein.

Another form of aneurism is the cirsoid aneurism, in which a number of arteries and their capillaries become dilated, tortuous, and thickened. It usually develops from abnormal congenital conditions, and should really be classed among tumours. Less frequently it is acquired. At one time a distinction was made between cirsoid and anastomotic aneurism, the former being a diffuse dilatation of already existing arterial branches, with perhaps their capillaries and veins, while the latter was looked upon more as a tumour resulting from the new formation of dilated and elongated arterial branches.

Fig. 16.—Arterio-venous aneurism of the temporal artery and vein caused by a punctured wound received twenty-five years before (Czerny).

But these two forms frequently have transition stages, so that a discrimination can not be made between them. The region of the ear and temples is a favourite place for cirsoid aneurism. It seems to be most common in women, in whom a tardy commencement of menstruation and frequent pregnancies are predisposing factors. The differential diagnosis between a cirsoid and an arterio-venous aneurism is sometimes difficult.

In cirsoid aneurism more or less of the skull is covered by tortuous, pulsating bluish vessels. The greater part of the skull, in fact

the entire scalp and surrounding parts, have been found involved in the aneurism. A pulsation can always be readily made out in this diffuse tumour-like mass, which is synchronous with the apex beat. The tumour can easily be emptied by pressure, but becomes filled again as soon as the pressure on the afferent artery is stopped. The growth of the aneurism is sometimes rapid, sometimes slow. The most prominent subjective symptoms are headache, vertigo, and ringing in the ears. There is always danger of a sudden hæmorrhage from rupture through the thinned skin. Marked destruction of the cranial bones is as yet unknown. For the symptomatology, diagnosis, and treatment of aneurisms, see the Principles of Surgery, § 95.

A well-recognised form of treatment is that by pressure, and particularly digital pressure, or pressure by means of rubber bandages, or a pad and spring. The surest method is extirpation of the aneurism after central and peripheral ligation of the main artery, and all the branches which go off from the aneurism (Antyllus). Moreover, simple ligation of the artery at a point proximal or distal from the aneurism has met with success.

In cirsoid aneurism as well, and in arterio-venous aneurism, when there is a dilatation of the smaller branches, extirpation is the surest form of treatment, and may be done while employing compression of the afferent vessels, or after tying off the tumour on all sides with catgut ligatures. In the case of extensive tumours, a preliminary step to extirpation will be the ligation of the afferent artery—for example, the external carotid or each of its branches—or the tumour is surrounded with multiple catgut ligatures passed through the skin and around the separate vessels. Ligation of the common carotid is too dangerous, owing to the changes thus brought about in the cerebral circulation, which may lead to a softening of the brain; it almost always results fatally from embolism of the brain or thrombosis of the basilar artery, as in Bruns's case, illustrated in Fig. 17. Very extensive cirsoid aneurisms have been removed after first making multiple incisions about them at different sittings, and ligating the vessels that were met with. Other

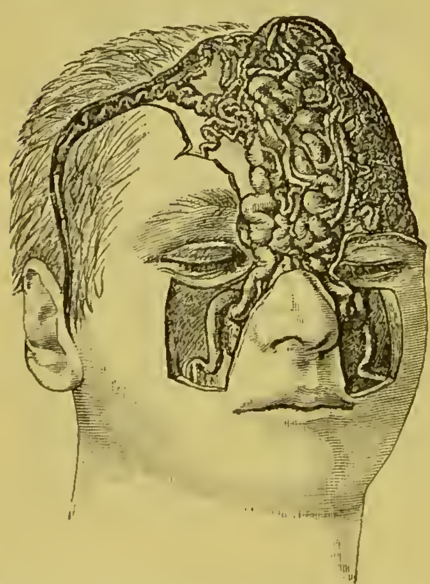


FIG. 17.—Cirsoid aneurism of the angular and anterior temporal arteries on both sides in a man twenty years old (Bruns). Ligation of the right external carotid and left common carotid. Death from cerebral embolism.

methods include ignipuncture—i. e., punctate cauterization with the fine point of a Paquelin thermo-cautery or galvano-cautery—and injections of alcohol with a hypodermic syringe. Injection of absolute alcohol should be tried before an operation is resorted to. The employment of caustics and the injection of the tincture of iodine, or of liquor ferri chloridi, is obsolete, and somewhat dangerous. For the treatment by galvano-puncture see under Treatment of Aneurisms of the Aorta, § 131.

Aneurisms of the cranial bones and of the middle meningeal artery are described in § 11.

§ 5. **Tumours of the Scalp.**—We shall first take up epithelial tumours. Of these, papillomata, or warts of different sizes, often pigmented and covered with hairs, are not infrequent, especially on the hairy

Fig. 18.—Warty hypertrophy of the scalp in a young girl twenty years of age (Billroth).

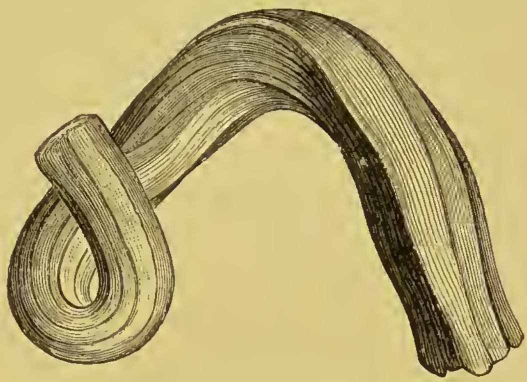


Fig. 19.—Cutaneous horn, fifteen centimetres in length, removed from the forehead of a woman ninety years old (Pagenstecher).

portion of the scalp. In rare cases there is a diffuse warty hypertrophy of the cutis (Fig. 18). As a result of frequent slight traumatisms, as in combing the hair, the warts often bleed easily. They sometimes increase in size, and change into large cutaneous horns, especially on the forehead, or they take on a malignant character and develop into epitheliomata.

The cutaneous horns, the favourite place for which is the hairy portion of the scalp and the frontal and temporal regions, are sometimes warts with an over-production of epidermis, and sometimes they grow out from sebaceous glands or hair follicles, or from sebaceous cysts. In rare cases a cutaneous horn may develop from the base of an epithelioma; or, *vice versa*, as a result of irritation of the horn by caustics, a cancerous ulcer may develop at its point of attachment. Fig. 19 represents a cutaneous horn of very unusual size, observed by Pagenstecher. Cutaneous horns have a translucent yellow or dirty brown colour, and are made up of horny epidermis cells without nuclei, close-

ly compacted. In very rare cases true bony tissue has been found within them which never has any communication with the underlying bone, but is a result of ossification inside the papillæ. Cutaneous horns and warts are best removed by the knife or scissors, under antiseptic precautions. Warts may also be destroyed by the cautery, by tying them off, or by caustics such as chromic acid, arsenic paste, etc.

The scalp is, moreover, a favourite place for sebaceous cysts or atheromata. They form soft, tense, usually hairless tumours, situated in or beneath the skin, and are to be looked upon as retention cysts of the hair follicles. They are usually as large as a hazelnut or walnut, but they can grow to the size of an apple, a fist, or even larger, and are often multiple. They contain epidermis, fat, and cholesterin crystals, and in old cysts the contents may be more or less calcified. The deeper subcutaneous atheromata develop from involuted skin-germs, which contain sebaceous glands, or they are true dermoids. Sometimes sebaceous cysts break through the skin, become inflamed, suppurate, or even change into epitheliomata, and hence their extirpation is always indicated. As a result of inflammation and suppuration, with the formation of fistulæ and ulcers, the capsule of the cyst may slough out, causing a spontaneous cure. Lücke has seen sarcomatous degeneration of an atheroma. In very rare cases an atheroma by its growth erodes or even perforates the skull, so that, owing to the transmitted pulsation of the brain, a so-called pulsating atheroma results. It is, however, possible that in these cases there has been a confusion with dermoid cysts.

In the extirpation of an atheroma care must be taken to remove the entire wall of the cyst, as otherwise a recurrence may result from portions of the gland left behind, or a fistula may persist. As a local anæsthetic cocaine or ether spray may be used, or crystals of menthol may be rubbed over the part. By tying a rubber bandage around the forehead one can operate without loss of blood. The hair should be shaved over a sufficiently large area. One can avoid cutting into the wall of the cyst if one makes a small incision through the skin at the base of the atheroma, then frees the cyst on all sides with a probe, and finally, after dividing with scissors the already separated skin, completes its removal. It is often unnecessary to suture the wound, as its edges fall together very well. After the removal of small cysts the wound may be dressed simply by applying English sticking plaster which has been made aseptic by soaking it in 1-in-1,000 bichloride or three-per-cent carbolic acid. In the case of large atheromata it is a good plan to put on an aseptic protective dressing, as illustrated in Figs. 4 and 5.

The dermoid cysts of the scalp in their external appearance resemble atheromata very closely, except that they are deeper, being, in fact, situated beneath the aponeurosis and attached to the periosteum. The favourite situations for dermoids of the skull are the upper outer orbital region, the orbital fossæ, the glabella, the temples, the neighbourhood of the mastoid process, and the anterior fontanelle. They are always congenital, and result from strayed embryonic cells of the epidermis. They grow very slowly, and are usually not noticed until puberty, or later.

According to Mikulicz, the development of dermoid cysts of the upper, outer orbital region stands in a causal relation to the involution of the epidermis for the formation of the rudimentary lens; that of the glabella to the development of the primary nasal pits, or to the coalescence of the fronto-nasal process with the maxillary processes. The dermoid cysts near the anterior fontanelle and in the occipital region stand in relation to the development of the brain.

The inner wall of the dermoid cyst, like the skin, consists of epidermis and cutis with sebaceous glands, hair follicles, and sometimes sweat glands. The contents are made up of a fatty, yellowish or white putty-like mass, containing hair, and often pieces of cartilage and bone. In large dermoids, such as those of the ovary, teeth are sometimes present, and very rarely brain, nerve, and muscle tissue. Occasionally the contents are oily (oil cysts), and in other cases serous in character. The oily material is due to fatty degeneration of the cells, with dissolution of the same, and is not the production of sebaceous glands or structures resembling the same. The contents may become calcified and disappear. Dermoids are sometimes situated in a hollow of the bone, in which case they are surrounded by a bony wall. Even complete disappearance of the underlying bone has been observed, and in other cases the defect in the bone was congenital. In such cases, owing to the transmitted pulsation of the brain, so-called pulsating dermoids result.

For the diagnosis of dermoid cysts of the scalp, their location in one of the above-named regions is important; moreover, as compared with the atheromata, which resemble them, they are more deeply situated, being under the aponeurosis, and almost always connected with the periosteum and bone. A pulsating dermoid cyst can hardly be mistaken for a hernia cerebri, as the latter occurs in other regions of the head, and can usually be made smaller, or made to disappear by pressure. In doubtful cases aseptic puncture or exposure of the tumour by an incision will clear up the diagnosis.

The treatment of dermoid cysts consists in their extirpation with

aseptic precautions. In case there is a defect in the bone, the rules of asepsis should, of course, be especially rigidly carried out. Pulsating dermoids have also been cured by injections of tincture of iodine, chloride of zinc, or alcohol. However, the disturbances are often so slight that the extirpation of the pulsating dermoid is not absolutely necessary.

Among other cysts of the scalp the rare serous cysts may be mentioned which are usually found in the occipital region. Out of eight cases five were in the occipital region. According to Heincke, they are to be explained as meningoceles which have become tied off *in utero.* In fact, they have been usually found over gaps in the skull which were covered by a membrane. Occasionally cysts result from the encapsulation of cerebro-spinal fluid after fracture of the skull.

The treatment of serous cysts consists in incision or extirpation; the latter is to be recommended in the case of cysts which are movable on the subjacent parts. In doubtful cases an exploratory puncture should be made previous to the operation. Adenomata of the sweat and sebaceous glands have been described by Verneuil, Rindfleisch, and others.

Epitheliomata of the scalp are most common in the frontal and temporal regions, and make up, according to Bergmann, 5·33 per cent,

Fig. 20.—Epithelioma of the frontal region, in a girl of fourteen, which perforated the skull (Braun).

Fig. 21.—Epithelioma (ulcus rodens) of the scalp, of twenty years' duration, in a man of fifty-six.

and according to Heincke, 6·28 per cent of all epitheliomata of the skin. The superficial ulcerating form is the most common, but deeply situated infiltrated epitheliomata are not infrequent. Warts, cicatrices, and atheromata are often the starting point of an epithelioma. Occasion-

ally an epithelioma of the scalp is found in young individuals. For example, Lossen saw an epithelioma resulting from acne in a girl eighteen years old, and Braun removed successfully an epithelioma in a girl fourteen years old which had extended to the dura and the outer surface of the brain (Fig. 20). Epitheliomata of the scalp sometimes form, as seen in Figs. 20 and 21, very large ulcerating surfaces, which may involve the entire forehead or the temporal region as far as the median line of the head. Bone as well may be attacked and destroyed, so that the dura and even the brain becomes involved, as seen in Braun's case illustrated in Fig. 20. The superficial ulcerating epithelioma, sometimes called ulcus rodens, usually runs a slow course; in the case illustrated in Fig. 21 the disease had lasted for twenty years. It takes a comparatively long time for the neighbouring lymph glands to become involved; the ones most commonly affected are those above the zygoma, behind the ear, near the angle of the lower jaw, and at the back of the neck. Infection of more distant lymph glands is rare in this form of epithelioma. Death usually results from increasing exhaustion or some intercurrent disease, and rarely from an involvement of the brain.

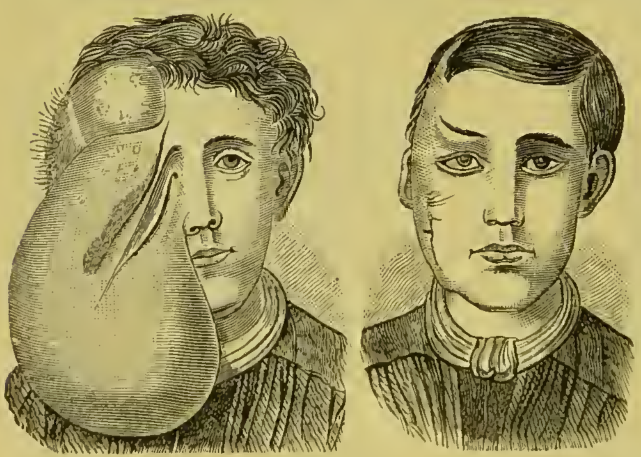
The treatment of epitheliomata of the scalp consists in their extirpation, and, if necessary, a portion of the underlying bone may be removed in case the epithelioma is attached to the same. If the bone is already involved in the disease, it must be chiselled away through its whole thickness; and if the dura is also diseased, it should likewise be removed as completely as necessary. Bleeding is stopped by ligation or cauterization. The defect in the bone thus made may be covered by flaps of skin, or in the way described on page 55. The escape of the discharges from the wound should be provided for by careful drainage. Finally the wound is dusted with iodoform powder and an antiseptic protective dressing applied which covers the entire scalp, and, if necessary, the neck. Thiersch used, in one case, chloride-of-zinc paste. After a few weeks the scab thus formed was cast off, and underneath was found a layer of brain tissue from two to three millimetres in thickness, which had become necrotic. Cerebral symptoms were not present. In spite of the apparently thorough removal of the epithelioma by the paste, a recurrence promptly made its appearance in the wound. In case one wishes to use a caustic paste in treating epitheliomata of the scalp, Vienna paste is to be recommended. It is applied to the ulcerating surface in a dry form, and produces its action without causing much pain. It forms a firm scab, and works slowly into the tissues beneath.

In the case illustrated in Fig. 21, after excision of the ulcer and re-

moval of a portion of the bone with a chisel, I grafted pieces of skin directly upon the bone, which healed in place without any disturbance. In this case also a recurrence took place very promptly, and the patient, after twenty years of suffering, put an end to his life in an attack of melancholia.

Of the connective-tissue tumours hard fibromata of the scalp are rare, the soft variety being more common, and sometimes forming large pedunculated or more diffuse soft tumours which hang down over the face.

A characteristic example of such a tumour is illustrated in Fig. 22. This was successfully removed by Lücke in three operations. The tumour was first noticed, when the patient was four years old, in the right temporal region. The diffuse soft fibromata form a transition stage to elephantiasis of the skin. A less marked degree of diffuse hypertrophy of the skin and subcutaneous connective tissue of the scalp is sometimes found in women as a result of frequent pulling on the hair when it is being dressed. Moreover, some of the moles on the scalp are soft fibromata. Occasionally soft fibromata are found in great numbers on different parts of the body. These multiple fibromata of the skin are sometimes the size of a pea or a walnut, and sometimes form very large, soft tumours which cause disturbances in the general nutrition of the body. In some cases we have to deal with leprosy. According to the researches recently made by Recklinghausen, the multiple fibromata of the skin start from the connective-tissue sheaths of the cutaneous glands, vessels, and nerves.



A *B*

Fig. 22.—Fibroma molluscum of the scalp and face in a labouring man twenty years of age, which began in the right temporal region sixteen years before. *A*, before, and *B*, after operation (Schultze, in the Strassburg Clinic).

Moreover, mixed fibromata occur on the scalp—viz., fibro-myxomata, fibro-myomata, and fibro-sarcomata. The so-called plexiform neuromata of the scalp are neuro-fibromata, and represent a nodular fibrous degeneration of branches of a particular nerve, which become tortuous and thickened. They are fairly common on the scalp, especially in the temporal and supraorbital regions, on the upper eyelid, etc. The development of these neuromata dates back to

the fœtal period; they are characterized by a very slow growth, and are sometimes very tender on pressure. They give the external appearance of loose flaps and folds of skin which are usually pigmented and covered with hair, as in elephantiasis. They are usually situated

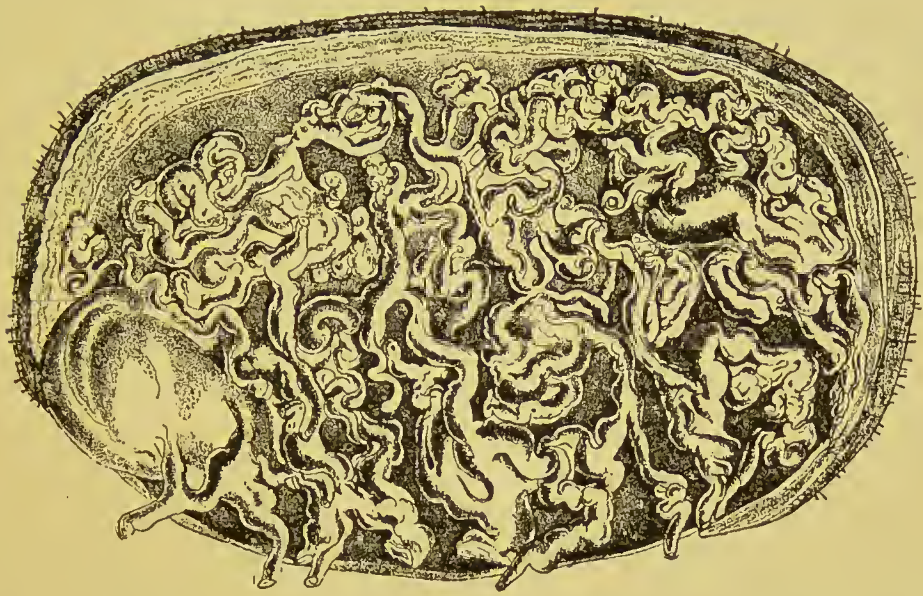


Fig. 23.—Plexiform neuroma; section of a plexiform neuroma of the lower half of the face on the right side, the post-auricular region and the right side of the neck in a boy of ten (Bruns).

in the subcutaneous cellular tissue, and the nodular cords can often be plainly felt. Sometimes they are combined with marked hypertrophy of the skin and cellular tissue, forming large tumours, so that some of the soft fibromata are really plexiform neuro-fibromata. We mentioned above that, according to Recklinghausen, soft fibromata sometimes start in the nerve sheaths.

As regards the operative treatment of large, soft fibromata, such as the one illustrated in Fig. 22, it is a good plan to remove the tumour at several operations. Billroth operated twenty times in one case of a large, soft fibroma. As in elephantiasis, the tumour can be removed by excising at the different sittings cuneiform pieces, and then suturing the wounds thus made. In the case of pedunculated tumours, which are very vascular, the use of the galvano-caustic snare is to be recommended. Enough healthy skin is to be kept, if possible, to cover the wound completely after removal of the tumour. The success obtained by Lücke in the case illustrated in Fig. 22 is an excellent one from a cosmetic point of view; the eyelids are in their normal position, and the previous deformity of the face has almost completely disappeared.

I removed by one operation an extensive soft fibroma which in-

volved almost the entire scalp, and then, after checking the hæmorrhage as completely as possible, I covered the large wound surface with skin-grafts. The result was all that could be desired.

Among hard fibromata the keloid should be mentioned, which is a tumour-like fibrous degeneration of a cicatrix in the form of a dense ridge, which often sends out cordlike processes into the surrounding healthy tissue. It is characteristic of keloids that they almost always recur after extirpation.

Angeiomata are not infrequently found on the scalp, but are much more common on the face. Out of 376 angeiomata of the head, Heineke found that 127, or 33·77 per cent, were on the scalp. They are either congenital or acquired, as the result of an injury. I saw in one case an angeioma which resulted from a contusion produced by forceps during delivery. Some congenital angeiomata remain stationary or disappear entirely, while others develop more or less rapidly into tumours varying in size. A distinction may be made between capillary, arterial, and venous angeiomata. Practically, however, there are but two varieties—viz., the simple angeioma (telangiectasis, nævus, plexiform angeioma), consisting of dilated and newly formed capillaries, small veins and arteries; and the cavernous angeioma, which consists of cavities lined with epithelium and filled with fluid or coagulated blood, similar to the corpus cavernosum of the penis. There are numerous transition forms between each of the two main varieties.

There are, moreover, venous blood tumours or cysts which communicate with the dural sinuses, and sometimes exhibit a well-marked pulsation. They are either congenital, idiopathic, or traumatic in origin. Mastin describes two forms: 1. Diffuse tumours resulting from traumatic perforation of the vault of the skull and the wall of the underlying sinus; in this way an extravasation of blood takes place beneath the scalp which becomes transformed into a blood cyst communicating with the corresponding sinus. 2. Venous tumours resulting from a dilatation of the walls of veins which can have their origin in a sinus, the emissary veins, and veins of the diploë. The latter variety is the most common, and is usually due to a varicose dilatation of an emissary vein. Operative procedures are only seldom necessary, and consist in tying off the pedicle of the tumour or in the employment of galvano puncture.

The simple angeioma is very frequently congenital in the form of a birthmark. Angeiomata are often pigmented and covered with hair, and are very frequently combined with a fibroma, lipoma, or sarcoma. Pigmented marks are sometimes the starting point of a malignant melano-sarcoma which grows rapidly and may prove fatal in a short

time by the formation of metastases. For this reason it is advisable to remove large pigmented spots as soon as possible, especially if they increase in size.

The treatment of angeiomata consists, when possible, in their removal by the knife, or in the employment of ignipuncture—i. e., punctate cauterization with the fine point of a Paquelin thermo-cautery or a galvano-cautery. In large angeiomata the excision of wedge-shaped pieces, with or without ligation of the afferent arteries, is to be recommended. Operations upon very extensive angeiomata, especially the form known as cirsoid aneurism (angeioma arteriale racemosum), may be made comparatively bloodless by applying a wet-rubber bandage over the hairy portion of the head and then taking one turn with a piece of tubing or a rubber bandage about the forehead and temples. Moreover, parenchymatous injections of tincture of iodine, liquor ferri chloridi, absolute alcohol, and liquor Piazza (sodium chloride fifteen grammes, liquor ferri chloridi [thirty per cent] twenty grammes, and distilled water sixty grammes) have been successfully employed; but, as already stated, they are not without danger.

Lipomata of the scalp are not common; they occur in the form of pedunculated or more diffuse tumours. They are situated either in the subcutaneous adipose tissue or beneath the aponeurosis, and under the fascia of the temporal muscle and the frontal portion of the occipito-frontalis. In rare cases enormous lipomata are found, as in a case reported by Roger, which was that of a negress, thirty-five years old, who had had since the age of two a lipoma of the left parietal and frontal regions reaching down to the knee; the left eyelids and the left ear were displaced downward, the left eye was drawn forward, and the nose and mouth were very much deformed.

Enchondromata and osteomata have been found in rare cases on the scalp. Heineke found in the literature two cases of enchondroma (Weber and Israel); the tumours, which were made up of hyaline cartilage, were not connected with the bone. Ossification of an enchondroma may give rise to an osteoma. Baumüller has described an ossifying enchondroma of the scalp, observed in Kraske's clinic, and Bruns reported a very large osteoma of the scalp resulting from ossification of an atheroma. The development of both of these kinds of tumour is probably due to the existence of strayed cells of cartilage or periosteum.

The cholesteatoma is a tumour which was at one time classed either as an atheroma or a dermoid. More recently Eppinger and others have shown that the cholesteatoma is really an endothelioma—i. e., a connective-tissue tumour. It results, according to these authors, from

growth of the endothelial cells of the vessels, the cells of the sheaths of the vessels, and the endothelium of the lymph vessels and lymph spaces. In some cases, however, the cholesteatoma is probably due to proliferation of epithelial cells. It has characteristic, often silklike contents consisting of fat, cholesterin, and masses of cells, which shine like mother of pearl. On the skull it is most common in the petrous bone and the membranes of the brain.

Malignant endotheliomata have also been found on the head—for example, in the form of the plexiform angeio-sarcoma or villous sarcoma, the latter being most common in the coverings of the brain. The plexiform angeio-sarcoma is anatomically very easily mistaken for a carcinoma, and it runs a similar course. Köster and others designate malignant endotheliomata as endothelial cancers.

Sarcomata are found on the head in very different forms; they originate in the soft parts, in the periosteum, in the diploë of the cranial bones, or in the meninges. Melanosarcomata, as stated above, often start from pigmented spots in the skin. The pulsating sarcomata of the scalp are particularly interesting—i. e., sarcomata with very much enlarged and very numerous vessels, and made up of cells of a marked endothelial character; they are also designated as angeiosarcomata or endotheliomata. According to Stierlin, they are really endotheliomata.

For the other pulsating tumours of the head see under Aneurisms, Tumours of the Bone, Dura, and Brain, Hernia Cerebri, etc. Guttmann observed an echinococcus cyst of the scalp.

In regard to the operative treatment of malignant tumours of the head see page 31. Heuck has found twelve cases in literature of operative removal of malignant tumours of the skull by resection of the cranial bones and by excision of a portion of the dura. In five cases the dura was excised, and in seven cases the bones of the skull resected. Seven of the cases were cured for the time, two died later from recurrence, and one from a brain abscess.

CHAPTER II.

INJURIES AND DISEASES OF THE CRANIAL BONES.

Injuries: Contusions and wounds of the cranial bones.—Fractures of the skull: Fractures of the vault.—Fractures of the base.—Separation of the sutures of the skull. —Injuries of the cranial bones in the fœtus and during birth. *Diseases* of the cranial bones: Inflammatory processes: Periostitis, osteomyelitis, ostitis, tuberculosis, syphilis, necrosis.—Atrophy and hypertrophy of the cranial bones.—Aneurisms of the cranial bones and of the middle meningeal artery.—Tumours (enchondroma, osteoma, sarcoma, fungus of the dura mater, chloroma, echinococcus cysts).

§ 6. **Contusions of the Cranial Bones** occur either alone or in conjunction with fractures. Uncomplicated contusions, such as those caused by a fall, a blow, a spent ball, or a grazing gunshot wound, are characterized by hæmorrhages within the substance of the bone or the diploë, and between the periosteum and bone, as well as between the latter and the dura mater. Their further course depends principally upon the condition of the soft parts. If there is a wound of the scalp inflammation and suppuration may take place, followed, perhaps, by periostitis and osteomyelitis, which may go on to meningitis, sinus, thrombosis, with pyæmia and septicæmia.

Besides being contused, the skull, and particularly the brain, may become severely shaken up. As a result of the contusion and concussion of the bone, fissures may be caused, pieces of bone may be broken off from the outer or inner table, or even complete fractures may occur. If, at the same time, the brain has been very much shaken up, the symptoms off concussion result, or in the case of a large intracranial hæmorrhage the symptoms of compression (see §§ 13, 14).

Uncomplicated contusions of the cranial bones run their course without symptoms; the extravasations of blood above and beneath the bone, as well as in the diploë, become absorbed; the periosteum, which has been lifted up, resumes its normal position, and a complete restitution takes place. The symptoms are very different in case an infection of the external wound has taken place, followed by inflammation, suppuration, cellulitis, erysipelas, or osteomyelitis of the diploë, resulting in pyæmia, meningitis, or septicæmia. All these infectious wound

diseases can be prevented by careful antiseptic treatment of the wound, begun as soon as possible after the injury. Separation of the periosteum from the bone does not necessarily result in necrosis, but the latter is likely to occur after suppuration, and the more extensive the suppuration the more probable the necrosis. Caries of the cranial bones may also result from contusion of the periosteum and the bone.

The final results of a contusion of the bone sometimes consist in thickenings of the bone, in the form of flat hyperostoses or irregular prominences. These usually disappear again, or they develop into permanent exostoses on the outer or inner table of the skull. Occasionally neuralgia in the soft parts and bone follows. In the case of any severe contusion of the bone the brain may also be injured, and hence it is not uncommon for cerebral disturbances to make their appearance at a later period. These secondary cerebral disturbances are sometimes caused by anatomical changes at the site of injury, consisting in circumscribed thickenings of the bone or firm adhesions of the membranes of the brain with the bone.

Purely subcutaneous contusions of the cranial bones require no special treatment in mild cases other than that given to simple contusions of the scalp. In case a wound of the soft parts is present, it should be treated according to general antiseptic principles. When the bone has been laid bare over a considerable area, it is advisable to cover it with plastic skin-flaps. The remainder of the treatment is symptomatic. For the treatment of concussion, compression, and contusion of the brain, see §§ 13–17. Secondary diseases, such as caries and necrosis, should be treated in the usual way. Carious areas are to be removed with a sharp spoon or a chisel, and sequestra extracted.

§ 7. **Wounds of the Cranial Bones** are mainly incised and punctured wounds. All wounds of the bones of the skull fall into two large groups—viz., penetrating and non-penetrating wounds. The former involve the whole thickness of the bone, and hence enter the cranial cavity; in the latter an opening of the cranial cavity does not take place.

Incised wounds of the cranial bones are either linear (Figs. 24 and 27) or flap wounds (Fig. 25), or wounds with loss of substance of the bone (Fig. 26), which may involve its whole thickness, or only the outer table or diploë. Flap wounds and wounds with loss of substance are usually caused by obliquely directed blows in the frontal, temporal, and occipital regions, but they may also be the result of a vertically directed blow. The sharper the edge of the instrument, the smoother the edges of the wound in the bone. A sharp-bladed instrument can

cut through the bone and penetrate into the brain without the patient losing consciousness immediately. If a more massive or blunt instru-

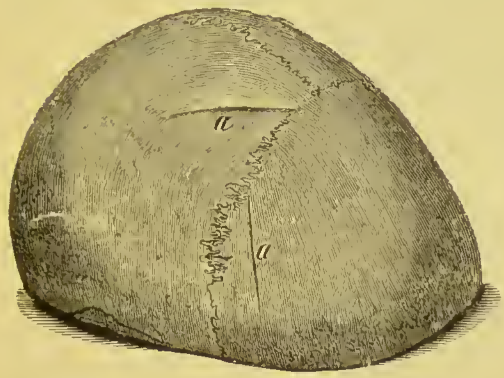


Fig. 24.—Two linear incised wounds (*a*, *a*) of the cranium that have healed (Pathological Institute at Leipsic).

Fig. 25.—Flap wound of the occipital bone (Pathological Institute at Leipsic).

ment is used, the edges of the wound in the bone are more likely to be splintered, and the injured person often collapses at once, as a result of the concussion of the brain. This splintering of the cranial bones by the use of blunt instruments is often confined to the inner table.

Fig. 26.—Healed wound of the bone with loss of substance (Pathological Institute at Leipsic).

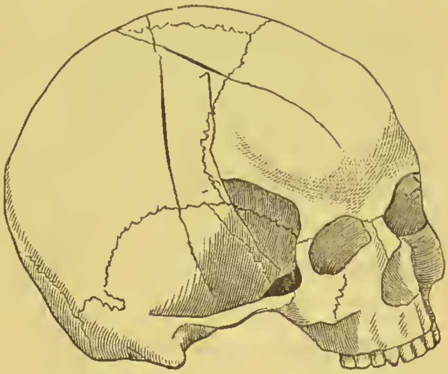


Fig. 27.—Extensive fissures of the skull from a sabre wound (Pathological Institute at Leipsic).

In all wounds of the bone, fissures often occur and may spread out over more or less of the surface of the cranium (Fig. 27).

The course of incised wounds of the skull is on the whole more favourable than that of a fracture caused by a blunt instrument or a fall. According to Bergmann, the mortality from this form of injury amounted in the American civil war to thirty and two tenths per cent. If treated antiseptically, this mortality is much smaller even in war. The best prognosis is given by non-penetrating wounds. In flap wounds in which there is a splintering and chipping off of a portion of bone the healing process often requires a long time, as

the sequestra become separated very slowly. Even completely separated fragments of bone can heal in place again under aseptic treatment. The splinters of bone sometimes become displaced from their normal position and heal in place at another point. After healing has taken place the injured region resumes its normal appearance, or osteophytes, hollows, grooves, or holes with a membranous covering remain permanently (Fig. 28). The defects are either a result of the injury or are due to secondary necrosis.

Fig. 28.—Incised wound of the skull with loss of substance which has partially healed by new formation of bone (Pathological Institute at Leipsic).

The principal danger in penetrating wounds of the bone consists in a spreading of the inflammation and suppuration to the cranial cavity, and especially to the membranes of the brain, resulting in meningitis. The latter is most surely prevented by a strictly antiseptic treatment of the wound. Instead of meningitis, secondary abscess of the brain occurs less commonly, and is usually due to the penetration of a splinter of bone from the inner table, or of some foreign body through the dura into the substance of the brain. Another danger may be hæmorrhage within the cranial cavity. The superior longitudinal sinus is most commonly injured, less often the middle meningeal artery.

Punctured wounds of the cranium are usually made by a knife, sword, dagger, bayonet, arrow, etc. The bone is penetrated more or less completely, and not infrequently the dura and the brain are pierced. Simultaneous injury of the dura and brain is one of the chief dangers from punctured wounds. It is also a matter of great importance that comparatively often the point of the instrument breaks off and remains behind, either in the bone, the dura, or the brain. In such cases meningitis and brain abscess are to be feared, particularly if the point was dirty and covered with microbes. The microbes, however, are, as it were, rubbed off during the passage of the instrument through the bone, and hence one can understand that foreign bodies of this kind may remain within the brain for years without causing symptoms, and be discovered accidentally at the autopsy. Bergmann mentions, in his work on Injuries of the Head, several cases of this sort. Moreover, an abscess can be present within the brain for months or years without causing symptoms until it suddenly gives rise to threatening manifestations which result in the death of the individual (see § 20, Abscess of the Brain).

In punctured wounds the sides of the canal may be splintered, and this is the more marked the blunter and more wedge-shaped the instrument used.

Among disturbances of function resulting from wounds of the bone the following should be mentioned: Attacks of vertigo and headache, epilepsy, mania, weakening of the intellect, and hemiplegia.

The diagnosis of wounds of the cranial bones is usually easy in the case of incised wounds, as the external wound generally gaps sufficiently; but it may be difficult to make out whether the cranial cavity has been opened or not. Hence careless probing with non-aseptic probes is to be avoided. Careful inspection of the wound and examination with an aseptic finger are usually sufficient. In the case of punctured wounds it may be necessary to enlarge the wound in order to find out whether it contains a foreign body or not. Complete division of the bone may be suspected if there is a visible pulsation in the wound, especially after irrigation with 1-in-1,000 bichloride. It is unnecessary, as far as the treatment is concerned, to determine the presence of fissures.

Every wound of the bones of the skull should be treated like a compound fracture; it is only in this way that one can be sure of preventing inflammation and suppuration, meningitis, pyæmia, and necrosis of the bone.

After shaving off the hair, disinfecting the wound and the field of operation, and arresting the hæmorrhage, the question arises whether one should suture the wound or not. An experienced surgeon, who is sure of his antisepsis, may close fresh wounds, even penetrating ones, making use of short drainage-tubes. Generally speaking, the same rules hold here as for wounds of the soft parts, which were given in § 2. Very frequently, especially when the soft parts are contused, it is more advisable to leave the wound open or to suture it only partially. In case drainage and suture are employed, the dressing must be removed after twenty-four hours, in order to take out the drainage-tubes. If there is much swelling and suppuration of the wound, the sutures should be immediately removed.

In the case of flap wounds in which there is a connecting pedicle of soft parts an attempt should be made to heal the bone flap in place again, and this is most likely to succeed if suppuration is prevented. If the flap is too severely contused, or if inflammation and suppuration are already present, the surgeon will probably be obliged to remove the bone flap and relinquish all idea of healing it in place.

If portions of bone with their covering of soft parts have been completely severed from all their connections, it will be necessary to cover the defect in the bone by means of pedunculated skin flaps or by skin grafts. Defects involving the whole thickness of the bone should be

treated in the way described on page 55. Splintering of the bone, especially of the inner table, is treated in the same way as in fractures of the skull.

In case of hæmorrhage from the middle meningeal artery it may be necessary to enlarge the wound with the chisel and tie the artery.

Bleeding from a sinus usually yields to compression in the wound. For the treatment of injuries and inflammations of the brain and its membranes, see §§ 12 to 23.

The treatment of punctured wounds requires but few words, as the general rules given for the treatment of incised wounds apply here. It is of the utmost importance to determine whether or not there is a foreign body in the wound. If so, it may be necessary to enlarge the wound and remove the body with forceps. Frequently it is necessary to chisel away the bone surrounding the foreign body.

§ 8. **Fractures of the Vault of the Skull.**—Fractures of the skull involve either the vault or the base, or both are fractured simultaneously.

Fractures of the vault are the most common variety, and are usually caused by direct violence, such as from a blow, kick, fall, or bullet. They are less often caused by indirect violence.

The fracture involves either the entire thickness of the bone, or it is confined to the outer or the inner table. Fractures of the inner table alone are not as rare as at one time thought. Occasionally fragments of bone are completely chipped off from the inner table, while on the outer table there is only a fissure, or a very superficial injury.

Bergmann, in his work on Injuries of the Head, mentioned thirty cases of fracture of the inner table without any apparent injury of the external table.

We distinguish, according to the character of the solution of continuity of the bone, the following forms:

1. *Fissures* of the bone, which are analogous to the crack in a plate. They pass either vertically or obliquely through the entire thickness of the bone, or they are confined to the external table or more commonly to the internal table. The latter has far less power of resistance, and hence the name "vitreous table." For the same reason, fissures of the internal table, in penetrating fractures of the skull, often extend over more surface than those on the outer table. Fissures are either simple or forked, and vary greatly in length. They sometimes spread to the base of the skull, cross over sutures, or run along in them, particularly in young individuals. It is of practical importance that sometimes one or both edges of the fissure are depressed below the surface.

2. *Comminuted Fractures with or without Fissures.*—In a comminuted fracture there are several fragments present of different sizes, and a portion of the skull may be completely broken up into small pieces. A comminuted fracture is sometimes stellate in form, the separate lines of fracture running out radially from a central point. In the most serious cases of comminuted fracture—resulting, for example, from a fall from a great height or from an injury

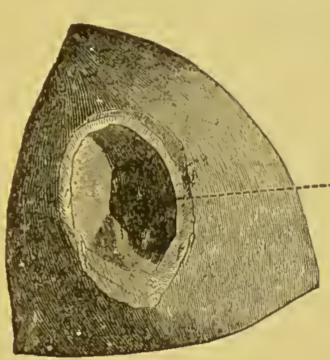


Fig. 29.—Depressed fracture of the skull seen from the outside, resulting from a fall upon a pointed stone. The fissure, *a*, passes through only the external table (Bergmann).

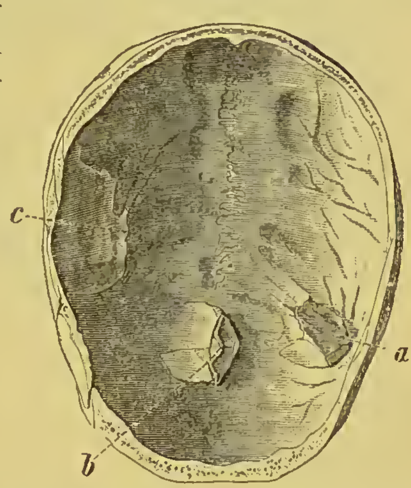


Fig. 30.—Depressed fracture of the skull seen from the inside. This skull belonged to a man who was killed by being struck on the head several times with a hammer; *a*, *b*, *c*, depressed fractures (Bergmann).

inflicted by machinery or from a cannon shot—the entire vault of the skull may be shattered into numerous fragments. Hofmann, Buchner, and others have reported cases in which the skull was broken into twenty, thirty, and even ninety pieces.

Displacement of the fragments, especially toward the cranial cavity, is of great importance in comminuted fractures, giving rise to the so-called depressed fractures (Fig. 29 and Fig. 30). The depression is due to the fact that the bone is bent or pressed inward beyond the limit of its elasticity.

3. *Fractures with Loss of Substance* are most commonly caused by gunshot injuries, and occur with or without splintering of the bone. If no fissures are formed, a hole with sharp edges is alone present, which looks as though it had been punched out. There is usually more loss of substance from the internal table at the point of entrance of the bullet than from the external table, but it is just the opposite at the point of exit. There are often numerous fissures which not infrequently connect together the points of entrance and exit. An excellent example of this is seen in Fig. 31. It is particularly in gunshot injuries at short range with an explosive action of the ball that such a shattering of the skull occurs as shown in Fig. 31. The

greater the momentum of the missile the more extensive the amount of destruction. The latter is a result of the rise in the hydrostatic pressure within the cranial cavity. The soft mass of brain tissue with its large percentage of water into which the ball passes receives, as it were, a bursting strength of its own and forces the skull apart. Among others, Busch, Heppner, and Kocher have made some very instructive experiments in this subject. In consequence of the explosive action of the ball, or rather the bursting force acquired by the incompressible brain, indirect fissures are formed which have no connection with the gunshot opening; in other words, indirect gunshot fractures result at a point in which the bullet did not come in contact. Messerer has collected from literature eighteen such cases of indirect gunshot fracture. A gunshot injury causes both a direct local fracture at the points of entrance and exit, and indirect fractures as a result of the hydrostatic pressure within the skull. On skulls from which the brain has been removed gunshot injuries never cause indirect fissures.

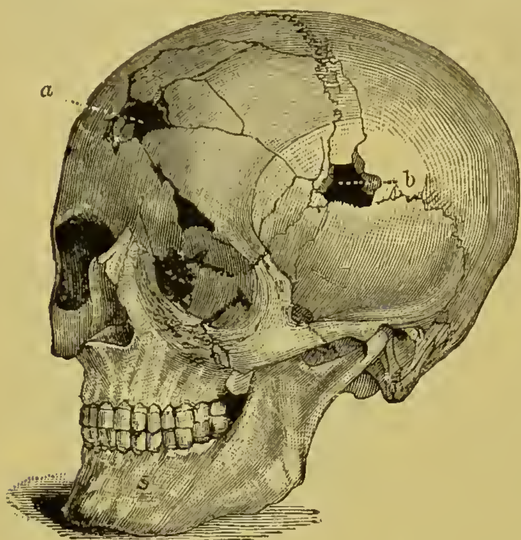


FIG. 31.—Gunshot fractures of the skull in a Russian soldier killed at Plewna; *a*, entrance opening; *b*, exit opening (Bergmann).

The most favourable form of gunshot injuries are, generally speaking, the grazed and furrowed wounds with or without penetration into the cranial cavity. Even in graze shots, however, with a slight amount of depression, fragments may be broken off from the inner table and driven into the brain.

Balls with slight momentum may give rise to a depressed fracture, and the ball not infrequently remains within the bone. Lead balls change their shape in different ways or are split in pieces. The missiles used in the modern guns consist of a lead foundation and a steel or nickel jacket. These bullets, especially the steel-jacket kind, retain their shape when they strike bone, do not break up, and hence cause smoother and more cleanly cut wounds. They possess a tremendous penetrating power, shatter the skull at a great distance, and lodge within the same much less frequently than the earlier lead bullets. Not infrequently the missiles heal up in the bone, and even in the brain.

The Mechanism of Fractures of the Vault of the Skull.—In order to understand the way in which fractures of the vault of the skull come about, the

fact should be borne in mind that both the bone in itself and the skull as a whole are elastic. The action of pressure or a blow upon a certain portion of the skull causes it to break as soon as the limit of the elasticity of the bone at this point is exceeded; if the latter does not occur, the bone, owing to its elasticity, returns to its normal position. It is readily understood, from Fig. 32, why it is that when only a bending in of the bone takes place the less resistant internal table may be pulled asunder, while the external table is merely impacted and forced inward, but not broken. Moreover, it can be understood why in a complete fracture the bone is first broken on its inner surface and later on its external surface. A similar explanation may be given for the fact that in gunshot injuries in which the ball makes only an entrance-opening and, after entering the cranial cavity, strikes the inner table on the other side, it sometimes shatters at this point the external table alone (Teevan).

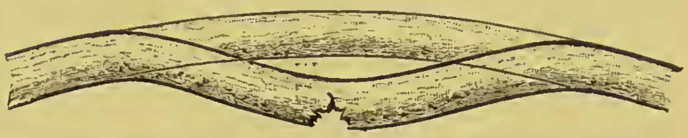


Fig. 32.—Mechanism of fracture of the internal table alone (Schematic).

Moreover, the skull as a whole possesses a certain degree of elasticity which Messerer has recently computed by exact measurements. When force is applied over a large surface, as in the case of a fall from a height, the skull is compressed in the direction in which the force acts, and lengthened or pulled apart in a direction at right angles to this. Two kinds of fracture can result in this way—viz., a "compression fracture" at the point where the skull is pressed together by the direct violence (Fig. 33 *A*), and a "bursting fracture" at those points where the skull has been lengthened and pulled asunder. The latter form of fracture is caused by indirect violence—i. e., at a point where the original force did not act. When we take up the mechanism of fractures of the base we shall return to this question more at length. It was formerly thought that these indirect fractures of the skull were fractures by *contrecoup*—that is, it was believed that the vibrations of the skull wall propagate themselves along the surface of the skull according to fixed rules, and can become concentrated on the opposite side of the head in such a way as to cause a rupture in the continuity of the bone. Bergmann, Messerer, and others have, however, proved the incorrectness of this theory. An exact knowledge of the mechanism of fractures of the skull is also of great importance from a medico-legal point of view. Körber has shown in thirteen selected cases of fracture of the skull caused by the action of massive forces that the above division into "compression fractures" and "bursting fractures" is really the correct one. The

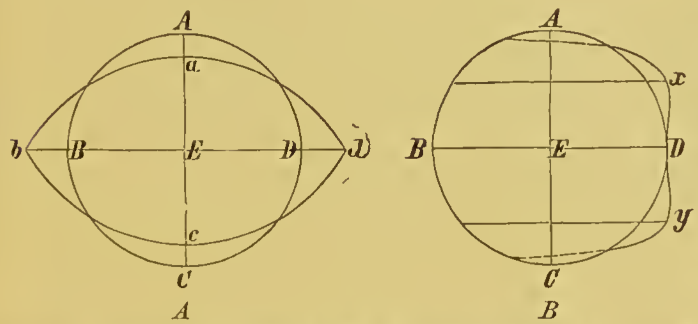


Fig. 33.—Schematic representation of the mechanism of fractures of the skull by compression and bursting.

direction of the force determines the direction of the fracture. The bursting fractures run parallel to the axis of compression, while the compression fractures are at right angles to the axis of compression. The compression is either unilateral or bilateral, which is a matter of medico-legal importance.

In the production of gunshot fractures there are present, as mentioned above, both the direct local fractures at the points of entrance and exit of the ball and the indirect fractures resulting from the hydrostatic pressure within the skull—i. e., the brain, with its large percentage of water into which the bullet strikes, derives, as it were, an energy of its own and forces the bones apart.

The course and prognosis of a fracture of the vault depend, generally speaking, upon whether vital parts of the brain have been injured or intracranial hæmorrhage is present. Fractures of the base are, as a rule, more dangerous than those of the vault. Of the latter, fractures in the temporal region are probably the most unfavourable, as in these the middle meningeal artery is very often injured and the fracture frequently extends to the base of the skull. Moreover, all gunshot fractures have a very bad prognosis. According to H. Fischer, among 8,132 gunshot injuries of the skull in the North-German united army during the Franco-Prussian War, 3,668 (45·1 per cent) resulted in immediate death, and nearly half of those found dead on the field of battle had wounds of the skull (47·4 per cent).

The brain either suffers a simultaneous concussion or contusion, or it is injured by a splinter of bone. In still other cases the brain suffers in consequence of lack of room due to a depression of the fragments or to a gradually increasing intracranial hæmorrhage. When we come to speak more fully of cerebral compression we shall take up the question of the effect of diminished space upon the brain; but it may be emphasized here that the brain can endure very well a certain amount of this diminution, and hence trephining is not, as at one time, indicated in every case of depressed fracture. The brain accommodates itself up to a certain point to the diminished space principally by crowding the cerebro-spinal fluid into the spinal canal, and hence symptoms of compression of the brain are often absent in depressed fractures. It is also well known that, especially in the case of children and young persons, depressions sometimes disappear soon after the injury. In one case reported by Volkmann a depression in a child six months old could no longer be made out at the end of twenty-four hours.

It is, moreover, in many cases not the depressed bone that causes the cerebral symptoms, but rather the contusion of the brain and the hæmorrhage between the bone and dura mater. This does not, how-

ever, mean that a depression of the bone can not by itself cause symptoms of compression, and that trephining is never indicated. On the contrary, there are many cases on record where trephining with elevation of the depressed bone or its edges has caused the unconsciousness and paralyses to immediately disappear.

It follows, from what has been said, that the symptomatology of fractures of the vault of the skull depends largely upon the manifestations on the part of the brain. The latter are caused (1) by concussion of the brain, (2) by intracranial hæmorrhage (compression of the brain), or (3) by injury of a particular portion of the brain (contusion of the brain). For a more detailed description of the symptoms, see §§ 13–18. I will only emphasize here that the symptoms of concussion of the brain appear immediately after the injury; they consist, according to the degree of concussion, in disturbances of the intellect (stupor, coma, delirium), vertigo, headache, nausea and vomiting, and changes in the body temperature (increase or diminution), pulse, and respiration. In compression of the brain, on the other hand, by an intracranial extravasation of blood, such as one following hæmorrhage from the middle meningeal artery, the behaviour of the patient is quite different. There is here always a period of freedom from symptoms, and unconsciousness and paralyses do not appear until after a certain length of time varying from four to twelve hours, when the intracranial hæmorrhage has become large enough to cause sufficient diminution of room in the cranial cavity. It is still open to question whether there is danger for the patient from aspiration of air after injury of a sinus of the dura mater in case of compound fractures. Contusion of the brain gives rise to certain focal symptoms, depending upon the portion of the brain injured.

Apart from injury of the contents of the cranium, including the brain and its membranes, it is of great importance for the further course of a fracture of the skull whether or not inflammation and suppuration take place at the point of fracture. This is particularly to be feared in the case of compound fractures of the skull, especially compound comminuted fractures, which have not received antiseptic treatment. The causes of the inflammation and suppuration are well known to us, and consist in infection of the wound with micro-organisms (see the Principles of Surgery, § 57 and § 67). As a result of the suppuration, necrosis of the bone is very apt to take place. In addition to this, cellulitis, erysipelas, meningitis, sinus thrombosis, brain abscess, pyæmia, and septicæmia are to be feared. Every suppurative process which spreads to the cranial cavity and extends itself here is fatal. The promptness with which a suppurative meningitis follows a compound

fracture of the skull and the incredible rapidity with which it sometimes spreads are illustrated in a case reported by Bergmann. The latter found, in the case of a Russian soldier in the Russo-Turkish War, who died thirty to forty hours after an injury to the head, suppurative meningitis of the convexity and base of the brain, which extended down along the membranes of the spinal cord as far as the cauda equina.

Simple fractures, on the other hand, are almost never complicated by inflammation and suppuration, because here there is no external wound through which an infection with micro-organisms can take place.

Beger made the interesting observation in the Leipsic clinic that injuries of the head, especially fractures of the skull, under the influence of an epidemic of cerebro-spinal meningitis, are very apt to become complicated with symptoms of meningitis.

Among the sequelæ of fractures of the skull may be mentioned psychic disturbances, attacks of vertigo, and convulsions, especially epilepsy, which comparatively often makes its appearance as the result of irritation of certain areas in the cortex (Echeverria and others). Hitzig was the first to show that by electrical stimulation of the motor area of the cortex in the vicinity of the fissure of Rolando, at first local and later general, convulsions take place. The ultimate result of a fracture of the skull where a foreign body, such as a bullet, has healed up in the wound, always remains in doubt, as the patient may suddenly die years afterward from abscess of the brain or acute meningitis.

A simple fracture of the skull is sometimes followed by the appearance of a collection of cerebro-spinal fluid beneath the skin of the scalp. The soft, fluctuating tumour usually pulsates perceptibly. The cerebro-spinal fluid comes either from the subarachnoid space, or, in case of injury to the brain, it may come from the lateral ventricles. These cases should not be confused with hernia of the brain or of its membranes. The prognosis of this complication is unfavourable, one half of the recorded cases having died of meningitis. In the cases which recovered, the tumours were made to disappear quickly and permanently by the use of dressings which exerted pressure. Occasionally a circumscribed cyst persists after the gap in the bone has closed.

Repair of Fractures of the Vault.—The repair of fractures of the vault of the skull takes place as follows: The amount of callus is generally slight, and its formation slower than usual, so that the covering over of defects is often only incomplete. The callus is formed by the periosteum, the medulla, and, especially on the inner table, by the dura mater. Generally speaking, the formation of callus is more marked on the inner table than on the outer, so that not infrequently osteophytes result, which as a rule disappear again

gradually (Fig. 34). Bergmann thinks that this meagre and slow callus formation is due to the fact that the fragments are not movable upon one another. If the holes and gaps are not too large, they are in most cases gradually filled in with bone. but in other cases even fissures may be still open at the end of one or two years. On the other hand, very extensive comminuted fractures are sometimes observed to heal rapidly with very complete bony union, as in the case represented in Fig. 35. Short fissures and shallow indentations usually disappear without leaving any trace, while very long or gaping fissures are often closed only by growth of bone from the internal table and remain entirely open on the external table, forming a groove or furrow. The repair of fractures of the skull may be summed up by saying that the less the distance between the edges of the bone, the more complete the bony union, and if this distance is considerable, complete or incomplete fissures and gaps will result. In the case of comminuted fractures the lines of fracture usually remain permanently visible.

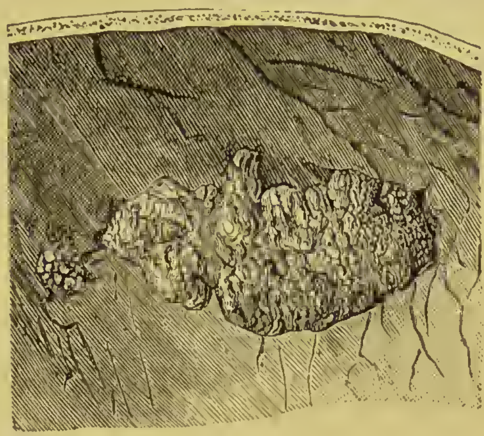


FIG. 34.—Papillary osteophyte more than a centimetre in height on the inner surface of the skull following a fracture (Pathological Institute at Leipsic).

In fractures with loss of substance the defect in the bone is only exceptionally covered in by the formation of new bone. As a rule, a membranous covering is formed, consisting of dense fibrous connective tissue. In defects of six to eight square centimetres, a bony closure is, according to Bergmann, not to be expected. But exceptional cases have been observed in which

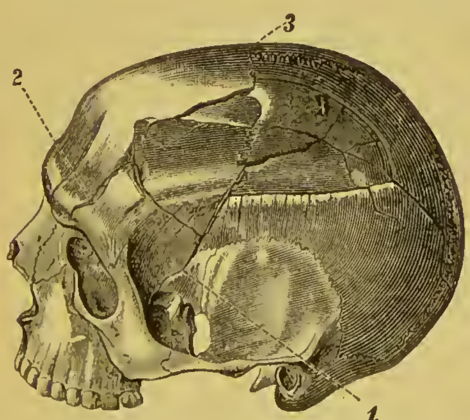


FIG. 35.—Healed comminuted fracture with numerous fissures (Bergmann).

FIG. 36.—Healed gunshot fracture of the skull: *a*, entrance opening; *b*, exit opening (Pathological Institute at Leipsic).

defects eight to ten centimetres in circumference have been completely filled in with bone, as in the cases reported by Küster, Bruns, and others. The regenerative power of the cranial bones sometimes seems greater than has been hitherto supposed.

That even penetrating gunshot wounds of the skull can heal up is proved by a skull in the pathological collection at Leipsic (Fig. 36). Bergmann mentions this skull, and states that it is the only healed penetrating gunshot wound of the skull which he has seen in a collection. The entrance opening in the frontal bone (*a*) is closed by newly formed bone, while the larger exit opening, which is also in the frontal bone, has remained a defect.

Completely separated splinters of bone may heal in place again in case of aseptically treated eompound fractures and in simple fractures. On the inner table broken-off splinters of bone may unite in such a position that the surface of the brain is constantly irritated by a projecting piece of bone, giving rise to epileptic convulsions. These convulsions may suddenly make their appearanee, with or without vomiting, after the fracture has been healed for months or years. They can also be caused by a brain abscess which has developed slowly as the result of a fracture of the skull.

In the case of simple fractures during the first years of life, especially in the first and second, the influence of the growth of the brain upon the lines of fractures and fissures is such that large gaps sometimes result, which may close again, but which usually go on increasing in size. Weinleehner distinguishes two forms: 1, those in which the brain forms the bottom of a gap, and 2, those with the formation of a eyst ("false meningocele").

Simple fractures of the skull may also, as already mentioned, give rise to the formation of cysts. These cysts, which are more or less perfectly developed, probably result either from a subperiosteal colleetion of cerebro-spinal fluid, owing to rupture of the membranes of the brain at the time of fracture, or there is a cystic metamorphosis of the extravasated blood that is present. Like the gaps in the bone, these cysts may disappear in time spontaneously.

Diagnosis of Fractures of the Vault.—The diagnosis of fractures of the vault of the skull is in the case of compound fractures readily made, as the line of fracture can be easily seen and felt. It is true that very small fissures are not infrequently hard to make out, but if the fissure eommunicates with the air, the blood can usually be seen to ooze from the line of fracture. Localized tenderness along the line of fraeture is another important diagnostic symptom. Pulsation of the brain in the wound points to a fracture which has involved the entire thickness of the bone and opened the cranial cavity. Such a pulsation can usually be made evident by irrigating the wound with bichloride or carbolic acid. If there is a defect in the bone, the pulsation is, of course, more easily recognised. But even though the dura mater is exposed, pulsation of the brain may be absent in the case of comminuted fractures if a fragment of bone is pushed underneath the surrounding bone. In such cases the wound should be carefully examined and the displaced bone removed as soon as possible. After its removal the pulsation of the brain becomes visible. If the dura has been injured the brain may protrude. Escape of cerebro-spinal fluid from the subarachnoid space in cases of fracture of the vault of the skull with laceration of the arachnoid membrane is rare. The cerebro-spinal fluid may also come from the lateral ventricles if there has been a deep injury of the brain. It is inadvisable to probe injuries of the head too much. In the case of simple fractures the skull should be carefully palpated in order to make out any

depression, fissure, or sharp edges of a fragment. If there is much swelling, due to a large extravasation of blood, palpation of the site of fracture is difficult, and in such cases the blood should be removed by massage. In palpation of the skull one must be careful not to mistake sutures, Wormian bones, and depressions, either congenital or due to gradual atrophy of the bone, for fractures. A localized point of tenderness is of great value in making the diagnosis. The latter is easiest in the case of depressed and comminuted fractures, while simple fissures often escape recognition entirely. It is further of great importance to get as clear an idea as possible of the condition of the inner table. Generally speaking, the inner table is more likely to be shattered or otherwise injured the more marked the depression and the more localized the injury, in other words, the more circumscribed the fracture, as in fractures due to the blow of a hammer.

In diagnosing a fracture of the inner table alone, percussion and auscultation have been made use of, but as yet with little success. Certain brain symptoms are of more importance in this particular, such as vomiting and convulsions which may be caused by a splinter of bone which has been driven into the brain.

In all comminuted fractures one should examine carefully for any displacement of the fragments, especially toward the cranial cavity, and take the necessary measures to remedy it.

For the differential diagnosis between concussion, compression, and contusion of the brain, the reader is referred to the description of the symptoms given on page 47. In all fractures in the temporal region in which, some time after the injury, vomiting and progressive stupor make their appearance, an injury to the middle meningeal artery is highly probable.

The Treatment of Fractures of the Vault consists, above all, in preventing intracranial disturbances and remedying them as far as possible in case they are already present. The patient should be transported with the greatest care, especially in the case of gunshot fractures. The transportation of a compound fracture in a jolting wagon and over a rough road has proved fatal in many instances.

Simple fractures of the vault are treated by rest in bed in case there are no special cerebral symptoms. The intact covering of skin is the best barrier to inflammation at the site of fracture. Ice and antiphlogistic remedies are unnecessary, except in the case of marked congestion and severe headache. Ice should not be used for too long a time, as the callus formation may be thus materially interfered with. Furthermore, the diet should be restricted and the bowels moved regularly. The cerebral manifestations, in so far as they are due to concussion of the brain, also require no special treatment, and even a depression at the site of fracture may be left alone in case there are no symptoms of compression or injury of the brain. Depressed fragments six to eight centimetres in diameter and one to two centimetres below the surface have been known to cause no symptoms on the part of the brain (Berg-

mann). The diminution in the amount of intracranial space gradually regulates itself.

If, on the other hand, a depressed fracture gives rise to symptoms of cerebral compression, the latter are probably always due to an intracranial hæmorrhage, and in such cases it may be necessary to trephine, in order to remove the blood clots or arrest the hæmorrhage by ligation of the injured vessel, which in many cases is the middle meningeal artery. Under such conditions one must often operate promptly, especially if the symptoms of compression increase in severity.

In other cases simple depressed fractures are combined with contusion of the cortex of the brain. In these cases I agree with Bergmann that trephining in order to prevent future disturbances, such as epilepsy, is not indicated. Bergmann rightly emphasizes the fact that contusions of the brain may heal spontaneously, and that on the other hand it is doubtful whether we can by trephining prevent the secondary disturbances.

In simple comminuted fractures as well, operative measures are usually unnecessary. Should necrosis of a fragment occur, the sequestrum should be removed later on, after the cranial cavity has become shut off. If one or more splinters of bone have penetrated the dura mater, and symptoms are present which point to injury of the cortical substance lying beneath the point of fracture, trephining is indicated —i. e., the fracture is exposed, and sufficient bone chiselled away or the fragment removed. In such cases it is often very difficult to decide whether one should operate or not.

Treatment of Compound Fractures of the Skull.—As regards the treatment of compound fractures of the skull a distinction is made between those which are confined to a small area and those which are more extensive. The narrower the bounds of the fracture the more necessary are operative measures, but the farther the fracture extends over the vault—and it may be over the base—the less are we able or do we need to operate. Generally speaking, the treatment of compound fractures of the skull is the same as that of other compound fractures; in other words, we always strive to obtain primary union of the wound that is present by antiseptic measures. The sooner a compound fracture of the skull is subjected to antiseptic treatment, the more likely are inflammation and suppuration at the seat of fracture to be avoided, and the healing to be without reaction.

The antiseptic treatment of the injuries of the soft parts conform to the rules given in § 2. The fracture itself should be disturbed as little as possible, especially in case of extensive comminuted fractures. Fragments of bone which are still connected with the periosteum and

dura mater should be left in place, but those about whose preservation there is any doubt should be removed immediately. In case the middle meningeal artery is injured, it should be sufficiently exposed to make it possible to ligate it or pass a suture around it. The drainage-tubes should be short and reach only to the line of fracture. As regards suture of the wound, the general principles given in § 2 apply here. Bergmann is very much in favour of suturing the wound, while other surgeons prefer not to close it at all, or only partially, by means of tension sutures. The more experienced one is in antisepsis, the more justified he is in suturing the wound. It is a very good plan to leave the wound open at first and simply pack it, and after twenty-four to forty-eight hours put in secondary sutures. Wounds which are much contused should, as a rule, not be sutured. In case of loss of substance in the soft parts, it is advisable to cover over the fracture with skin flaps.

The wound may be dressed by dusting over it iodoform powder and then covering it with shaken gauze which has been wet in 1-to-1,000 bichloride of mercury and wrung out, over which moss cushions moistened in 1-to-1,000 bichloride or dry cotton are laid ; the entire dressing is then secured by gauze bandages in the way shown in Figs. 3 and 9. I now cover the wound with sterilized gauze, over which I lay sterilized absorbent cotton, and bandage the whole in place with sterilized gauze bandages. The patient must be carefully watched during the further course of treatment, and it is especially important to watch the temperature carefully. If the wound has been sutured, the first dressing must in any case be changed after twenty-four hours, in order to be able to inspect the wound carefully and remove here and there a suture or a drainage-tube. The antiseptic protective dressings should be continued until the wound has completely healed, and I make it a rule to change the dressings in compound fractures of the skull more often than usual.

If the patient comes under treatment with a compound fracture which is already inflamed and suppurating, the prognosis is less favourable. In such cases many surgeons make use of stronger antiseptic solutions for disinfecting the wound, such as five-per-cent carbolic acid, eight per-cent solution of chloride of zinc, etc., but 1-to-1,000 bichloride of mercury is probably strong enough.

In those compound fractures which are confined to a small area, and in which there are splinters of bone directed toward the cranial cavity, as in Fig. 30, trephining is necessary, in order to remove the projecting piece of bone.

Fractures of the inner table alone, of which the diagnosis is usually very doubtful, are treated according to general principles. If symp-

toms of compression due to intracranial hæmorrhage and focal symptoms make their appearance, trephining will be necessary.

Gunshot wounds are likewise treated in exactly the same way as other compound fractures. In all gunshot fractures one should make a careful examination with the eye and finger, and all completely separated fragments of bone or balls should be removed. Pieces of lead and splinters of bone are often driven into the brain, but it is wrong to probe around too much for them in the wound or in the brain. One should confine himself to removing from the brain only such splinters of bone and balls which can be directly seen or felt with the finger. Probing along the path of the bullet should be done cautiously or omitted entirely, and, unless special indications require the removal of the ball, one should give up looking for it. Balls and splinters of bone may heal up aseptically within the brain, sometimes without injury to the patient, and sometimes causing corresponding disturbances, such as epilepsy and paralyses. In a good many cases death has occurred suddenly from acute meningitis and abscess of the brain. Bergmann has collected a number of interesting cases of this sort. It is rare for foreign bodies to heal up inside the cranial cavity without causing disturbances later on.

In punched-out gunshot fractures the inner table is often extensively comminuted, and hence Bergmann recommends trephining and chiselling away the edges of the fracture; in this way it is sometimes possible to remove the ball from beneath the bone or from the brain.

It is often a matter of luck whether one finds the ball or not. Lead balls are often broken up into single fragments.

The treatment of the complications and other disturbances during the course of fractures of the skull has already been taken up in § 4, in connection with inflammations of the scalp. For the treatment of injuries and inflammations of the skull contents see §§ 13–23. The treatment of traumatic prolapse of the brain is given in § 18, and that of hernia cerebri in § 22.

In all inflammatory complications on the part of the scalp and the contents of the skull it is of chief importance that the situation be recognised early enough.

These complications are most sure to be avoided by early disinfection of the wound; but if a diffuse meningitis is already present, our therapy is as yet completely powerless.

The complete repair of fractures of the skull is often very much delayed by necrosis of splinters of bone or of the edges of the bone. When separated, the sequestra are easily removed, and then complete union usually follows very quickly.

Defects in the cranial bones of appreciable size may be protected from external injury by a leather pad or a metallic plate. In suitable cases the defect may be closed by transplanting small pieces of cartilage or bone from young animals or children, or by the use of decalcified bone plates after Senn, Kümmel, and others; in a comparatively short time the decalcified bone is replaced by normal bone. Another excellent method of covering in defects consists in the employment of pedunculated skin-periosteum-bone flaps, taken from the vicinity of the defect (Fig. 37). By this method a flap corresponding in size to the defect is raised, consisting of the soft parts, periosteum, and external lamina of the skull, just as in osteoplastic resection of the skull (§ 23). Even defects of considerable size can be successfully closed by these osteoplastic flaps. Eiselsberg and Hinterstoisser permanently closed defects in the skull in three cases with a celluloid plate two millimetres thick; the cutaneous wound healed by primary union. The celluloid plate is so fashioned that it fits very snugly into the defect. I have also successfully healed completely separated splinters of bone in place after previously warming them in a weak solution of bichloride of mercury (1 to 5,000 to 10,000) or in a 0·7-per-cent salt solution.

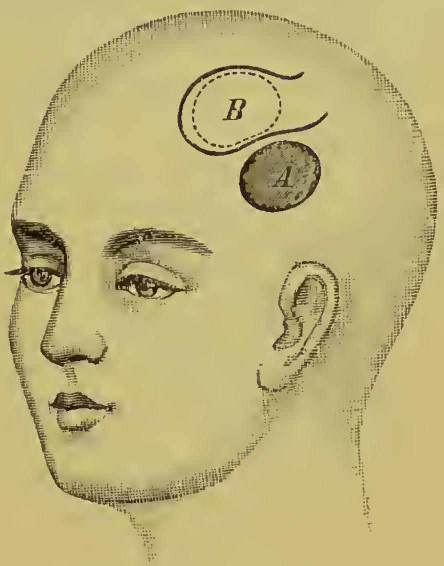


FIG. 37.—Osteoplastic restoration of defects in the skull: *A*, defect; *B*, pedunculated flap of skin, periosteum, and bone which includes the external table and a portion of the diploë.

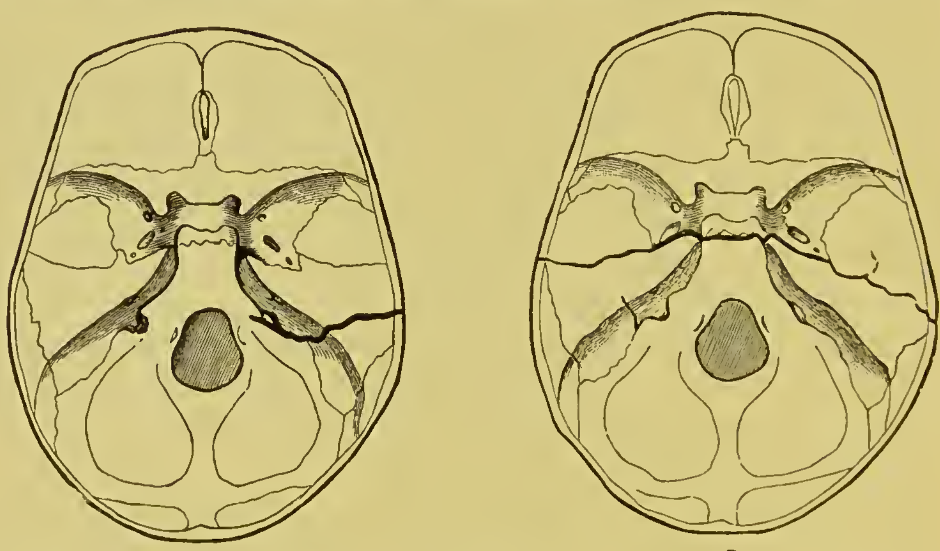
Leser has given some statistics concerning the value of trephining for fresh compound fractures of the skull, from observations made in Volkmann's clinic. Of thirty-six cases of compound fracture, thirty-two recovered, while four died as a direct result of the injury and not from the trephining. Among the thirty-two cases that lived there were eight gunshot fractures, and of these there were five cases in which the ball could not be reached. The dura mater was injured twenty times, the brain eleven times; in four cases drainage of the brain was resorted to; and twice prolapse of the brain took place, which, however, disappeared spontaneously. In each case the wound was thoroughly cleaned and disinfected, and in order to accomplish this and remove the foreign bodies, blood clots, and crushed tissues from the dura and the brain, trephining was undertaken in the majority of cases. The wound was drained, and where possible sutured. As dressing materials, iodoform gauze and moss cushions were used, while water-tight materials were discarded in order not to interfere with the drying of the dressings. The first dressing was changed after three to five days, and the

second was left on longer. Wagner, Thiersch, and others have likewise obtained excellent results from early trephining or enlargement of the wound in the soft parts and bone.

§ 9. **Fractures of the Base of the Skull** are usually indirect and caused by violence applied to the vault, less often to the facial bones or the vertebral column. Fractures of the base due to direct violence are rare if we leave gunshot fractures out of consideration.

The mechanism of fractures of the base has not only a scientific interest, but is also practically of great importance in their diagnosis and treatment. We distinguish here also direct and indirect fractures.

I. **The Mechanism of Indirect Fractures of the Base** has often been a subject of dispute, but it is only in recent times that it has been really understood and found to be dependent upon the elastic properties of the skull (Bruns, Messerer, Bergmann, and others). It was thought at one time that the vibrations of the skull wall propagated themselves according to certain



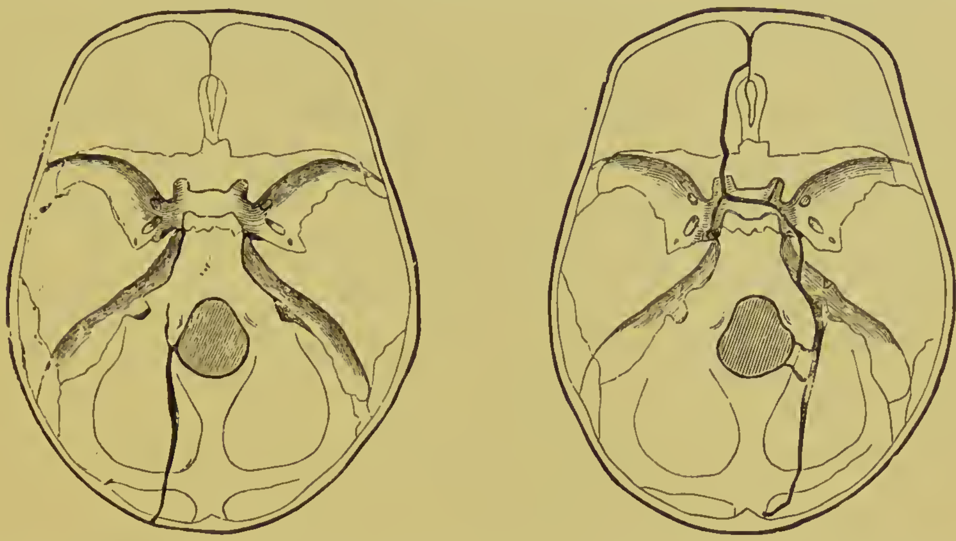
A *B*

Fig. 38 *A* and Fig. 38 *B*.—Partial (*A*) and complete (*B*) transverse fracture of the base.

laws, accumulated at points of the skull opposite those at which the violence was applied, and brought about here a rupture in the continuity of the bone (Saucerotte). According to Aran, fractures of the base are simply fractures by irradiation—i. e., the fissure always begins at the point where the violence is inflicted and then takes the shortest route possible to the base of the skull. Félicet likewise adopted in the main this view, and he also called attention to the fact that the architectural construction of the skull and especially of the base is of importance in the mechanism of fractures of the base. According to Félicet, the skull is made up of strong buttresses and weaker intermediate arches. The fractures of the base, according to his view, run along the weak arches, leaving the buttresses intact. This theory holds for a certain number of fractures of the base, but Félicet himself could find in

it no satisfactory explanation, as he too adopted Aran's view that fractures of the base are due to irradiation.

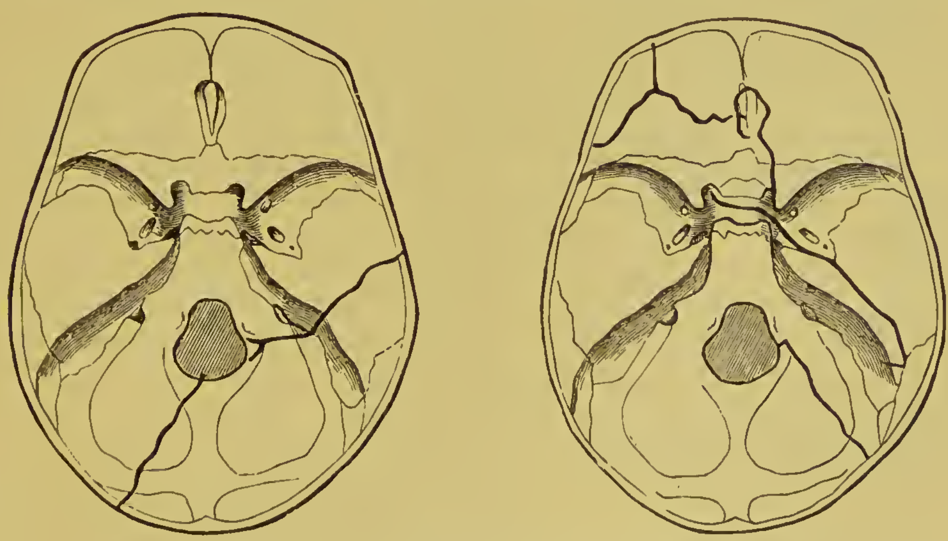
In order to have a correct understanding of the mechanism of fractures of the base, one must attach partieular importance to the fact that by the



A B

Fig. 39 *A* and Fig. 39 *B*.—Partial (*A*) and complete (*B*) longitudinal fracture of the base of the skull.

infliction of violence to the elastic skull a change in its form results. If the skull had a uniform thickness and power of resistance, the fissures could, as Bruns has said, be reckoned out mathematically. This is, however, not the



A B

Fig. 40 *A* and Fig. 40 *B*.—Diagonal fractures of the base of the skull.

ease. Stronger and weaker portions alternate both on the vault and more particularly at the base; the base also has many openings for vessels and nerves besides the occipital foramen.

Besides this elasticity, the point at which the violence is inflicted and its direction are of great importance. In accordance with the statistical facts collected by Schwarz, and the experimental investigations relating to the elasticity and strength of the cranial bones made by Messerer and Hermann, we at present agree with Wahl, Körber, and others, that fractures of the base always run in the direction of the violence that inflicts the injury, or parallel to the direction of the pressure; they are therefore not irradiated fractures, but fractures by bursting or compression. The fractures due to bursting run parallel to the axis of pressure, and those due to compression run at right angles to this axis. The compression may be unilateral or bilateral, a distinction which is of great importance from a medico-legal standpoint. As the experiments made by Messerer and Körber show, the fractures result either from a caving in of the skull at the point of greatest pressure, or from a bursting or pulling apart at the point where it is most stretched. We should keep distinct these two kinds of fractures—viz., those due to compression, which run at right angles to the axis of pressure, and those due to bursting, which run parallel to it. Thus, transverse compression of the skull gives rise to a partial or complete transverse bursting fracture of the base (Fig. 38), and compression of the skull in a longitudinal direction to a partial or complete longitudinal fracture of the same kind (Fig. 39), while in oblique compression the fracture has a diagonal direction (Fig. 40). All the illustrated types of fracture are taken from Wahl's work on this subject. Compression of the skull in a vertical direction between the vertex and the vertebral column gives rise to fractures by crushing or compression, which usually take the form of a circular fracture in the neighbourhood of the occipital foramen. This latter variety is most commonly caused by a fall upon the feet, knees, or buttocks, by which the vertebral column is pressed from below against the occiput, or, *vice versa*, the skull is pressed against the spine as in a fall upon the head (Fig. 41). These fractures can also be designated as fractures by *contre-coup*. In the same way a fracture of the base by compression may occur in the middle fossa from a blow or fall upon the chin which is transmitted by the lower jaw.

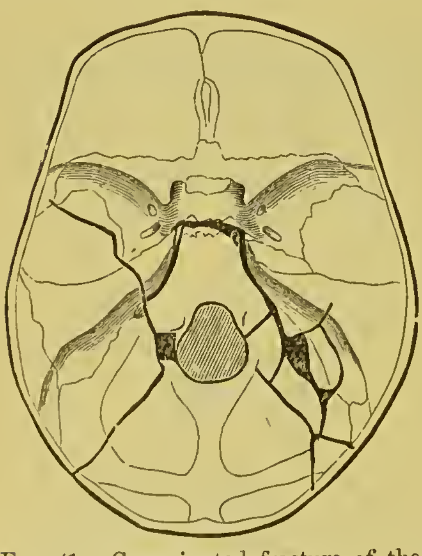


FIG. 41.—Comminuted fracture of the occipital bone from impact of the spine against the occiput in consequence of a fall upon the head or the feet or buttocks.

The two diagrams given in Fig. 42, which we have already mentioned in connection with fractures of the vault, may make what has just been said more plain. By compression of the skull in a vertical direction from the vault against the vertebral column (see Fig. 42 *A*), the sphere A B C D is changed into the ellipse *a b c d*. Fractures by compression may take place at the points *a* and *c* which have been pressed farthest from their normal position, while at *b* and *d* fractures by bursting result. If, on the contrary, the skull A B C D (see Fig. 42 *B*) is compressed

at D alone without counter-pressure—at the foramen magnum, for example—by a fall upon the feet, a fracture by compression may occur at D, and at the same time fractures by bursting may result at x and y, which represent the points of greatest bulging in the meridians A D and C D. The elasticity and strength of the skull being variable, the fractures by bursting are most likely to occur at the weakest part of the skull, which is the base. Hence this variety of fracture is very common at the base, and always takes place along one or more meridians parallel to the direction in which the force acts. Probably all indirect fractures of the base are, if we exclude the fractures by compression in the vicinity of the foramen magnum, fractures by bursting. The experiments made by Greder agree with this view. The irradiation theory of Aran and Félicet is accordingly incorrect. In the fractures of the vault as well, which extend to the base, the direction of the line of fracture is determined by the direction of the force or violence that inflicts the injury.

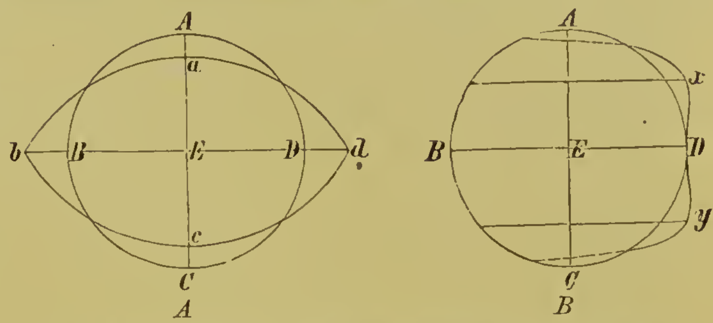


FIG. 42 *A* and FIG. 42 *B*.—Schematic representation of the mechanism of fractures of the skull by compression and bursting.

II. **Mechanism of Direct Fractures of the Base.**—Direct fractures of the base are much rarer than the indirect. They result most commonly from violence applied to the orbit and nasal cavity; for example, a fracture of the roof of the orbit with or without injury to the bulb, and often with injury to the brain, may result from a blow struck into the orbit with a knife, sword, the point of an umbrella, pitchfork, etc. A blow struck into the nasal cavity only very rarely gives rise to fracture of the cribriform plate of the ethmoid bone. The above-mentioned fracture by compression in the region of the foramen magnum, may also be regarded as a direct comminuted fracture, caused by a fall upon the top of the head, or upon the feet or buttocks, by which the spinal column is driven into the foramen magnum or against the occipital bone. Moreover, fracture of the glenoid cavity of the lower jaw by a fall or blow on the chin belongs in the same category. To the direct fractures of the base belong, finally, the gunshot fractures which in time of peace usually occur in persons who attempt suicide by shooting into the mouth or into the region of the ear or temple. A bullet shot into the mouth usually passes through the hard palate into the anterior fossa of the skull. In shots which pass through from one temporal region to the other the ball may penetrate the four lateral walls of the orbit without injuring the bulb, but both optic nerves may be divided.

We distinguish, then, four types of fractures of the base, leaving out of consideration gunshot fractures. These are: 1, transverse fractures; 2, longitudinal fractures; 3, diagonal fractures, which are all indirect fractures by bursting; and 4, direct comminuted fractures of the occipital bone.

Fractures of the base are usually simple linear fractures, chipping off of pieces of bone being less common. Projecting processes or ridges may be

broken off, such as the apex of the petrous portion of the temporal bone, the dorsum ephippii, or the clinoid processes. Severed fragments of bone of this sort may divide blood-vessels or nerves, or be driven into the brain.

Symptoms and Diagnosis of Fractures of the Base.—The most common symptoms of fractures of the base are: (1) Ecchymoses beneath the skin; (2) escape of blood and cerebro-spinal fluid, and sometimes of brain substance, from the ear and nose, and (3) functional disturbances of the brain and of the cranial nerves lying at the base.

Ecchymoses appearing beneath the skin of the eyelids, beneath the conjunctiva, the mucous membrane of the pharynx, or in the mastoid region, are most likely to mean a fracture of the base when direct violence has not been applied at the point in question. If considerable hæmorrhage takes place into the orbit from rupture of the ophthalmic artery and vein, marked exophthalmos may result, the ball being pressed forward by the extravasation of blood.

Hæmorrhage from the ear, nose, and pharynx should be made use of only cautiously in making the diagnosis of a fracture of the base.

On the other hand, the escape of cerebro-spinal fluid from the ear points to a fracture of the petrous portion of the temporal base, with rupture of the dura, arachnoid, and membrana tympani. According to Deroubaix, the escape of cerebro-spinal fluid from the ear is only possible when the serous sheath of the auditory and facial nerves is opened within the internal auditory meatus, and the fluid can come out from here through a fissure. The escape of cerebro-spinal fluid from the ear, with intact membrana tympani, signifies a fracture of the upper wall of the external auditory canal. With the membrana tympani intact, cerebro-spinal fluid may, in case of fracture of the petrous portion of the temporal bone, escape through the Eustachian tube into the pharynx or nose. Cerebro-spinal fluid may also pass into the nose, in fractures of the anterior fossa of the skull, through the ethmoidal cells. The amount of cerebro-spinal fluid that escapes is variable, but is probably greatest from the ear. In some cases one hundred to two hundred grammes flow out in twenty-four hours, or it may reach six hundred to eight hundred grammes. The fluid is at first hæmorrhagic, but later it is as clear as water. It is alkaline, is rich in sodium chloride, and becomes somewhat cloudy by boiling, owing to the small amount of albumen that it contains. However, not every serous fluid of this sort that escapes from the ear is cerebro-spinal fluid, as a lymphorrhœa may be present, resulting from an opening from some cause into Schwalbe's lymph spaces in the labyrinth. The escape of brain matter from the external auditory meatus and the nose is a sure sign of fracture, with rupture of the membranes of the brain, and injury to the brain.

Paralyses of single nerves at the base of the skull are particularly likely to result when the line of fracture runs through the foramina of exit, and the nerve is lacerated, crushed, or compressed. In other cases the paralyses are due to injury of the brain itself, such as extravasation of blood, laceration of the brain substance by splinters of bone which have been driven into it, etc. In such cases the paralyses are on the opposite side—i. e., in injuries of the left side of the brain the nervous disturbances are on the right side of the body. If, however, the nerves are paralyzed during their course at the base of the skull, then the paralyses are on the same side (see also § 16). The regional symptoms along the distribution of the separate nerves are of course of great practical importance, especially as regards the location of the fracture. In rare cases of fracture of the base the symptoms disappear entirely a few days after the injury, and it is only upon a more careful examination that one can make out that the soft palate is somewhat flattened out, the uvula lies to one side, and there is difficulty in swallowing. These symptoms are very easily overlooked, and too favourable a prognosis is given, for in such cases there is always a fracture of the pyramid of the petrosal portion of the temporal bone, involving one or both of the superficial petrosal nerves. If the large superficial petrosal is alone injured, then the above symptoms are the only ones present; but if the small superficial petrosal is also involved, there are painful sensations inside the ear.

Deafness and disturbances of equilibrium—i. e., attacks of vertigo, tottering gait, revolving movements, and sudden falling to the ground—are referred by many to injury of the semicircular canals (Menière). According to Böttcher and Bergmann, this view is incorrect, since the disturbances may, on the one hand, be absent, although the labyrinth is injured, and, on the other hand, be present with intact labyrinth. Böttcher obtained these disturbances of equilibrium in pigeons only when in searching for the semicircular canals parts of the brain were injured; if the injury to the brain was avoided, the disturbances in equilibrium never occurred after division of the semicircular canals.

Occasionally functional disturbances of the nerves at the base of the skull are observed without the presence of a fracture. This may result from compression of a nerve by an extravasation of blood in the corresponding foramen or in the cranial cavity, or from tearing away of the nerve. In some cases the paralyses do not come on until later, and may in this case be caused by inflammatory processes, such as ascending neuritis, and are then not infrequently the forerunners of a basal meningitis.

Sometimes air collects in the subcutaneous cellular tissue (emphysema), for example, in fractures through the orbits with opening of

the ethmoid cells, and in fractures through the other cavities of the skull that are filled with air, especially the frontal sinuses, the sphenoidal cells, and the nasal and tympanic cavities. After fracture through the mastoid cells, gradually enlarging and more or less permanent collections of air appear under the scalp (see page 22, Emphysema Capitis, Pneumatocele).

Prognosis of Fractures of the Base.—The further course and prognosis of fractures of the base are influenced mostly by any associated injuries to the contents of the cranial cavity, or to the large nerve trunks and the blood-vessels. Furthermore, inflammation and suppuration are more likely to result here, because micro-organisms gain access to the cranial cavity more easily, and cause a fatal meningitis by passing through the nasal cavity and the frontal and sphenoidal sinuses, or through the external auditory canal and the tympanic cavity. Even with the nasal cavity intact, pneumococci have been known to pass from the nose into the cranial cavity (Weichselbaum, Ortmann, Sammter). Sometimes purulent meningitis results, not from a contiguous spreading of the inflammation and suppuration, but from infection by the micro-organisms circulating in the blood. Meningitis may also result from infection by the microbes from the urethra, vagina, uterus, or alimentary canal. If the prognosis is not rendered unfavourable by the complications just mentioned, fractures of the base may heal very well. The prognosis of fractures of the border and roof of the orbit is relatively favourable; Berlin mentions, among twenty cases, seventeen recoveries. Puncture fractures of the roof of the orbit are less favourable. They are caused by the penetration of blunt or pointed objects, such as the point of a sword, knife, stick, umbrella, pitchfork, etc., and may be accompanied by serious hæmorrhage. They usually prove fatal very quickly. As Berlin in particular has shown by his elaborate investigations, fractures of the skull, and especially fractures of the orbit, result very frequently in disturbances of vision. In forty-three cases of fracture of the orbit, blindness on one side occurred twenty-seven times soon after the injury, and disappeared again in only one case. Even complete blindness has been observed after fractures of the skull, but it is sometimes only temporary. The disturbances of vision following fractures of the skull are due (1) to injury or compression of the optic nerve, for example, in fractures in the vicinity of the optic foramen; (2) to hæmorrhage within the sheath of the optic nerve; (3) to injury of the cortical centres of the optic nerve; or (4) to a descending neuritis following a localized process in the crebrum, or a diffuse basal meningitis.

The repair of fractures of the base takes place in the same way as that of fractures of the vault; here, also, the callus is small in amount and is formed slowly, and the same deviations from the normal occur here as in the repair of fractures of the vault (see pages 48–50).

In order to determine the location and probable course of a fracture of the base, one must find out through the history of the accident the nature of the violence and the direction in which it acted.

The Treatment of Fractures of the Base is essentially symptomatic, consisting in uncomplicated cases of rest in bed, light diet, and regulation of the bowels, as in uncomplicated simple fractures of the vault. For the fracture itself there is nothing that can be done; operative measures are impossible, as one can not reach the site of the fracture. In the case of fractures which penetrate into the middle ear the ear should be irrigated with boric or salicylic acid, and the external auditory canal plugged with iodoform gauze or cotton.

In fractures through the sphenoidal and ethmoidal cells our therapy is powerless, and death often takes place from meningitis. If suppuration makes its appearance anywhere and can be reached, as in the vicinity of the orbit or within the orbit, an incision should be made as soon as possible in order that an orbital cellulitis may not spread to the membranes of the brain. In compound fractures of the orbit an antiseptic protective dressing should be applied after carefully disinfecting the wound and examining it for any foreign bodies.

Wounds and cavities of the skull should not be irrigated and disinfected too much in treating fractures of the base. As several observations show, the irrigation of wound channels has often given rise to a fatal phlegmon, since the microbes were washed farther into the wound.

§ 10. **Separation or Diastasis of the Cranial Sutures** is either observed by itself, or, what is more common, in conjunction with fractures of the skull. According to Prescott, among sixty-eight fractures of the skull fourteen were combined with diastasis of the sutures. Only very great violence—such as from a fall upon the head, a falling beam, or a blunt, wedge-shaped body, which forces its way into the suture—can bring about separation of a suture, as the dentations interlock very firmly. They occur not only in young persons, but in adults as well. Owing to the great violence, the membranes of the brain, the sinuses, and the brain itself are often injured, and hence the prognosis is unfavourable. In case recovery takes place, there is either a bony or fibrous union of the bones. In young individuals the growth of bone is not interfered with. After extirpation of a suture in a young rabbit Gudden observed the formation of a new suture, and the

growth of the bone was not disturbed. Sutures are to be looked upon as the boundary lines of the normal-growing portion of the separate cranial bones.

The diagnosis of diastasis of a suture is, of course, easiest when it is exposed owing to a wound in the skin; but even in subcutaneous separations the gap can often be felt through the skin.

The treatment of diastasis is exactly the same as that of a fracture of the skull (see page 51).

Injuries of the Cranial Bones in Infants.—It may be well at this point to speak of injuries to the cranial bones in children, which in many ways are of interest to the physician.

In the first place, displacement of the bones of the skull may occur during the passage of the fœtal head through the pelvis, and it takes a particular form in the different presentations. Thus it is found in the ordinary occipito-frontal presentations that the occipital bone is pushed beneath the parietals, and the edge of one parietal bone overlaps the edge of the other. More rarely the two parietal bones override each other in a sagittal direction, so that one parietal bone comes to lie posterior to the other. This displacement of the cranial bones is especially common in the case of a narrow pelvis; it disappears again very quickly, and serious consequences are only to be feared when there is simultaneous intracranial hæmorrhage.

In the second place, changes in the shape of the skull occur during delivery, especially flattening of the cranial bones from pressure against the promontory of the sacrum, and the opposite—an increase in the convexity. In right occipito-frontal positions the left parietal bone is flattened. In the case of a narrow pelvis, forceps deliveries, and forcible extraction of the child, grooved, funnel-shaped, or spoon-shaped depressions may result. It is only rarely that these depressions are combined with fractures of the skull in the form of fissures, but a corresponding hæmorrhage almost always takes place beneath the skull (cephalhæmatoma). Here, also, the child's life is endangered only from intracranial hæmorrhage. But, as is well known, the child may die from asphyxia during the protracted birth.

Real fractures of the skull are only rarely observed in infants, and may then be due to pressure of the forceps (Fritsch), more often to pressure of the head against the promontory of the sacrum, or another part of the pelvis in case of disproportion between the head and the pelvis, and are then usually combined with a corresponding depression of the bones. Fractures of this sort are most common in the parietal bones. Congenital fissures and gaps should not be mistaken for fractures; the former occur only in certain regions of the skull, such as in the occipital and parietal bones, and are symmetrical (Hofmann).

The condyles of the occipital bone may be broken off by cephalotripsy and extraction of the head in breech presentations. Winckel has reported a case in which it occurred in an ordinary vertex presentation.

In some cases sutures are torn apart, especially the sagittal, coronal, and squamo-parietal.

The prognosis of the above-mentioned injuries and even of the fractures is favourable. It is only from intracranial hæmorrhage resulting in compression of the brain that death is likely to result soon after birth.

§ 11. **Diseases of the Cranial Bones.**—Of the diseases of the cranial bones we shall first take up acute inflammation of the periosteum and medulla—acute periostitis and acute osteomyelitis.

Acute Periostitis.—Acute inflammation of the periosteum of the cranial bones, the so-called pericranium (*periostitis acuta cranii*, *pericranitis acuta*), is usually the result of fresh injuries to the head which have not run an aseptic course, or it may follow inflammatory and suppurative processes which have already lasted some time, such as granulating wounds or ulcers of various kinds, necrosis of the cranial bones, suppuration in the middle ear and in the mastoid process, etc. Acute periostitis either exists by itself or is complicated by a cellulitis or erysipelas. The inflammation begins either primarily in the pericranium, or it results secondarily from the spreading of an inflammation in the neighbourhood, such as a cellulitis of the soft parts.

As regards the clinical course of acute periostitis, mild grades may occur which do not go on to suppuration, especially if an early incision is made. In other cases the inflammation is very severe from the outset and often begins with a chill, and is characterized by a high fever and a marked tendency to rapid extension, with a corresponding separation of the periosteum from the bone. In such cases a hard, very tender swelling is found over the inflamed portion of the skull, with œdema of the overlying skin and the adjacent parts, such as the face and neck. The skin is usually involved secondarily, and becomes reddened and œdematous. After the inflammation has lasted some days, fluctuation may be easily detected, pus in greater or less quantities escapes on making an incision, and the bone is bared of its periosteum over a variable area. After the escape of the pus the periosteum, which has been lifted from the bone, resumes its normal position without necrosis of the bone having taken place. Even when the periosteum is destroyed by suppuration, the exposed bone often does not become necrotic. The apparently dead bone, which has a white appearance, becomes covered, especially under aseptic treatment, with a red layer of granulation tissue, and a complete return to the normal can take place. In other cases necrosis of a larger or smaller area of bone occurs; it is usually superficial, and only rarely affects its whole thickness, as the blood supply of the bone from the dura is not altered. Separation of the sequestrum in necrosis of the skull is usually very slow. In case of extensive necrosis involving the whole thickness of the bone a corresponding defect

usually remains behind, as only small defects become filled in again with bone. During the separation of the sequestrum, in case of complete necrosis, the circumscribed demarcating suppuration may suddenly give rise to a meningitis, ending fatally.

By far the most dangerous form of acute periostitis is the septic, which is usually combined with septic osteomyelitis. These ichorous inflammations of the pericranium and the diploë of the cranial bones usually result fatally from septic meningitis, general sepsis, or sinus thrombosis and pyæmia.

The diagnosis of an acute periostitis of the cranial bones is made from symptoms similar to those in cellulitis of the scalp, which is so frequently present at the same time. In those inflammations which begin primarily in the pericranium the skin and subcutaneous cellular tissue are at first less affected than in the case of a diffuse cellulitis, the inflammatory swelling is very firm, deeply located, and extremely tender on pressure, while the skin itself is at first movable over this hard, painful tumour.

The prognosis of every acute suppurative inflammation of the pericranium of any extent must be given cautiously, as there is always danger, particularly of a fatal meningitis.

Treatment of Acute Pericranitis.—It is, in the first place, of the greatest importance, for the sake of prophylaxis, to treat all fresh injuries to the head, granulating wounds, old suppurative processes, etc., with the strictest attention to antisepsis. In this way suppurative pericranitis as well as cellulitis is most easily prevented.

The treatment of acute periostitis of the cranial bones, when already present, consists in making, as early as possible, an incision through the painful, infiltrated portion of the cranium down to the bone in order to relieve the tension and allow the pus to escape. One should not wait until fluctuation can be made out, but the sooner the incision is made before suppuration begins, the more favourable the course and the more likely will the formation of pus be prevented. Any wounds that may be present must be carefully examined and disinfected, while undermined sinuses are freely opened. In the case of a diffuse septic periostitis it may be necessary to make numerous incisions in order to allow the septic pus to escape freely, and short drainage-tubes are placed in the openings thus made, in order to be sure that the pus keeps on discharging for a sufficiently long time. Finally, an antiseptic protective dressing, consisting of iodoform, sterilized gauze, and cotton or moss pads, is applied. Dressings that exert much pressure are to be avoided, in order that the pus may not be pressed farther into the tissues. If necrosis of the bone is present, one should at first wait to see whether it does not subside. If, however, necrosis of the bone is assured and a line of demarcation forms, it is not necessary, as

is usually the case, to wait for a complete separation of the sequestrum, but, in order to bring about a more rapid healing, the necrotic bone may either be pried out with a periosteal elevator or cut away with the chisel and mallet until bleeding bone is reached. In these operations, as well as in the after-treatment of necrosis, the rules of antisepsis must be strictly adhered to.

Any resulting defects involving the entire thickness of the bone must be protected either by wearing a cap with a leather pad or metal plate, or they may be covered by a plastic flap consisting of skin, periosteum, and bone, by small pieces of bone transplanted from children or young animals, or by decalcified bones or celluloid plates (see Principles of Surgery, p. 144).

Acute Suppurative Osteomyelitis of the Cranial Bones usually results, like cellulitis and acute periostitis, from wounds of the head which have not run an aseptic course, especially if the bone has been fissured or shattered. The so-called idiopathic acute infectious osteomyelitis of the cranial bones caused by infection through the blood is extremely rare.

Acute suppurative osteomyelitis of the cranial bones begins either primarily in the diploë or secondarily after suppurative periostitis or cellulitis, and is caused by the *Staphylococcus pyogenes aureus*, less often by the *Staphylococcus pyogenes albus*, or by both together. Acute suppurative osteomyelitis is, in short, a phlegmon of the diploë of the cranial bones. The degree and the extent of the suppuration are variable. The periosteum is always and the dura mater frequently involved in the inflammation. It is only in exceptional cases that the suppurative inflammation is confined to the diploë—as, for example, in a case reported by Bilguer, which resulted from a superficial sabre-cut which did not perforate the bone. In this case, upon trephining, the pus flowed from the diploë alone, the periosteum and dura mater being intact. Here, too, there is danger of death from suppurative meningitis or sinus thrombosis with pyæmia which may be caused by a direct spreading of the inflammation along the veins into the cranial cavity by way of the foramina, and especially the emissaries, or pieces of infected thrombi become detached and are carried by the circulation to the interior of the cranial cavity.

In rare cases circumscribed chronic bone abscesses have been found in the diploë of the cranial bones after injuries to the head, and were healed by trephining.

The treatment of acute suppurative osteomyelitis is essentially the same as that of acute suppurative periostitis which has been described above. Here, also, one must provide for the escape of the pus and

disinfection of the focus of inflammation. Hence it may be necessary to remove the external table, or the inner table as well, with the chisel and hammer. It is often sufficient to scrape out the softened bone with the sharp spoon and disinfect thoroughly. By means of an antiseptic after-treatment aseptic healing should be striven for, and extension of the inflammation to the cranial cavity avoided (see also Treatment of Osteomyelitis, in the Principles of Surgery, § 104).

Osteophlebitis Cranii.—Inflammation of the veins of the skull is usually the result of infected wounds of the soft parts and bone. It is generally found in conjunction with acute osteomyelitis, and is very likely to prove fatal by causing meningitis, sinus phlebitis, sinus thrombosis, and pyæmia. The exposed bone, or its diploë, is in advanced and severe cases infiltrated with pus and of a greenish-yellow colour, just as in acute osteomyelitis. In such cases energetic measures must be adopted, and the bone which is infiltrated with pus chiselled away in its entire thickness, in order to save the patient from death from meningitis, sinus phlebitis, and pyæmia (Czerny, Bergmann, the author).

Chronic Inflammations of the Cranial Bones either result from an acute periostitis or osteomyelitis, or they are of a tubercular or syphilitic nature. We shall take up only tuberculosis and syphilis of the cranial bones.

Tuberculosis of the Cranial Bones is either a primary tuberculosis of the bone—i. e., a primary tubercular periostitis or osteomyelitis—or it is secondary to tubercular inflammation of the soft parts, such as the mucous membrane of the middle ear, for example.

Primary tuberculosis of the bone in the form of a primary tubercular periostitis or osteomyelitis most commonly attacks young individuals who are suffering from local tuberculosis in other parts of the body. Generally speaking, the cranial bones are but slightly inclined to tubercular disease. Its most frequent location is in the frontal and parietal regions, and usually makes its appearance in the form of a circumscribed, inflammatory, and œdematous swelling of the soft spots which is painful and tender on pressure. An abscess is gradually formed, but a spontaneous rupture of the circumscribed tubercular focus is difficult on account of the firm, resisting aponeurosis and the skin. Hence one can understand why it is that, in case operative measures are delayed very long, the caries may have already involved the whole thickness of the bone so that the dura or even the pulsating brain is exposed. In such cases death from tubercular meningitis or sinus thrombosis with general miliary tuberculosis is to be feared. Tubercular erosion of a sinus or of the internal carotid has also been

observed, for example, in tubercular caries of the petrous portion of the temporal bone.

Secondary tuberculosis of the bone may occur, for example, in the ethmoid bone from tubercular ulcers in the nose. Caries of the petrous portion of the temporal bone, which is of such frequent occurrence, is probably, as a rule, tubercular in nature, and results from tubercular inflammation of the tympanum (see § 76, Diseases of the Tympanum). Secondary tubercular caries may furthermore occur in other parts of the skull, especially on the forehead in conjunction with lupus.

The prognosis of tubercular caries is good in the sense that healing usually takes place after a suitable energetic operative treatment, but as other organs are usually the seat of tubercular disease, the prognosis is rendered much less favourable.

For the diagnosis of tubercular caries of the skull the typical circumscribed chronic inflammation, especially in the above-mentioned localities, and the usual presence of tubercular disease in other parts of the body, such as the skin and lungs, are of importance. The diagnosis is, however, rendered certain by the demonstration of the tubercle bacillus.

The treatment of tubercular caries of the skull consists in early and energetic operative measures—i. e., in incision, scraping with the sharp spoon, or chiselling out the tubercular focus until healthy bone is reached. It will sometimes be impossible to avoid opening the cranial cavity. If the caries has already opened the cranial cavity, a tubercular abscess is often found outside and inside the skull, and these are connected by a fistula which perforates the bone. In such cases the inner tubercular focus must be entirely exposed by chiselling away the bone, any sequestra that may be present removed, the dura scraped with the sharp spoon, and finally the outer abscess thoroughly excised. The wound is drained and either closed by sutures or left open. It is a good plan to close large defects by a flap of skin and periosteum taken from the immediate neighbourhood. The field of operation is then dusted over with iodoform powder and covered by an aseptic protective dressing of sterilized gauze, moss, wood wool, or cotton.

In case of secondary tubercular caries of the ethmoid bone, for example, or of other parts of the base of the skull, the diseased focus should be exposed in the same way and scraped out thoroughly with a sharp spoon. In case of tubercular caries of the petrous portion of the temporal bone the mastoid process is trephined (see Diseases of the Ear, § 78), and in tuberculosis of the ethmoid bone the nose may be split open in the median line or temporarily resected in the line of the

naso-labial fold (see Operations on the Nose, § 41). Should defects in the bone of considerable size result, they must be covered over by wearing a protective cap provided with a leather pad or metal plate. In suitable cases defects may be closed by transplantation of small pieces of cartilage or bone taken from children or young animals, or by the formation of pedunculated flaps from the immediate neighbourhood. The latter should consist of the soft parts of the scalp and outer table of the skull—i. e., a piece of bone of the proper size is chiselled out, leaving the diploë and inner table intact.

Syphilis of the Soft Parts and Bones of the Skull.—Syphilis occurs in the soft parts of the skull, as in other portions of the body, in the form of syphilides—for example, on the forehead, along the border of the hair (*corona veneris*). These syphilides on the head are either macular, papular, squamous, vesicular, or pustular. Moreover, circumscribed gummata are found on the scalp, especially in the skin, less often in the subcutaneous cellular tissue, aponeurosis, or occipito-frontalis muscle. These soft, boggy tumours, which are characteristic of syphilis, may disappear again gradually just as they began, particularly if a suitable antisyphilitic treatment is instituted. In other cases ulcers are formed owing to their breaking down and coming to the surface. Their size varies from that of a pea to that of a hen's egg. Sometimes spreading serpentine ulcers are formed from these gummata and from pustular syphilides, which gradually involve the periosteum and bone.

Premature falling out of the hair is another result of syphilis (*alopecia syphilitica*). The extent of this syphilitic alopecia, which usually involves the scalp in a uniform manner, is very variable, but it is seldom that complete or almost complete baldness occurs. The prognosis is favourable and the hair is, as a rule, completely restored, especially in young persons and under an antisyphilitic treatment. Circumscribed alopecia usually results from a deep ulcerative destruction of the skin of the scalp.

Syphilitic disease of the cranial bones is either secondary to syphilis of the soft parts or arises primarily in the periosteum, diploë, or endocranium. These different localizations can hardly be distinguished clinically. Bone syphilis occurs in the tertiary period, and its favourite locations are the frontal and parietal bones.

Syphilitic periostitis usually takes the form of circumscribed gummatous nodules, or it may appear as a more diffuse gummatous periostitis. Very often both forms are found together. Periosteal gummata are usually multiple, flat, elastic tumours which may reach the size of an apple. Inflammatory symptoms are absent, and they are ordi-

narily only slightly painful. They may remain unchanged for months or years, and disappear entirely under antisyphilitic treatment, in which case corresponding hollows in the bone usually result (see Fig. 43). In other cases they come to the surface, break down and slough. Here, also, they often run a course lasting for years, and very large defects involving the entire thickness of the bone may result, which, if healing takes place, become closed by a membranous covering (Fig. 44). Not a few patients, however, die of meningitis or sinus thrombosis.

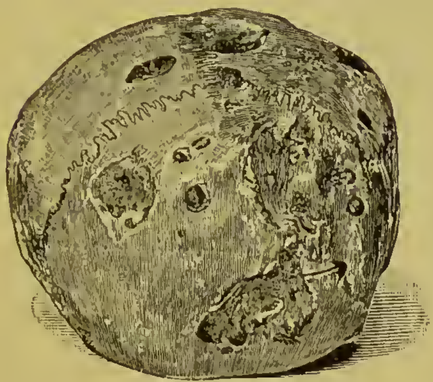


Fig. 43.—Syphilitic cicatrices in the cranial bones (Pathological Institute at Leipsic).

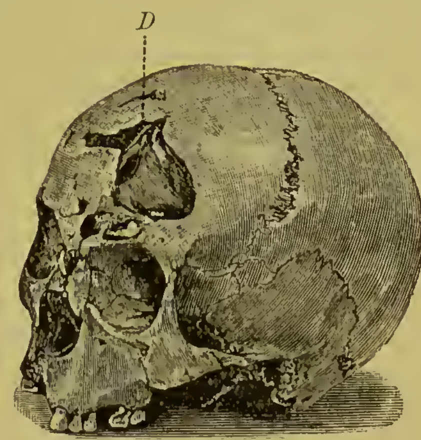


Fig. 44.—Syphilitic defect (*D*) of the frontal bone caused by a gumma (Pathological Institute at Leipsic).

Instead of circumscribed gummata there may be a diffuse gummatous periostitis that has a marked tendency to spread continuously and can lead to extensive carious destruction of the bone, which may be superficial or may extend through to the dura (see Fig. 45). This diffuse gummatous periostitis can often be plainly shown to be made

Fig. 45.—Extensive syphilitic caries of the skull caused by a diffuse gummatous periostitis (Pathological Institute at Leipsic).

Fig. 46.—Diffuse warty hyperostosis of the skull from syphilitic periostitis ossificans (Pathological Institute at Leipsic).

up of small circumscribed gummata. It may remain subcutaneous for a comparatively long time, until finally, owing to an increasing thinning of the skin, inflammatory complications, or traumatisms, it breaks through and leads to profuse fœtid suppuration, in the course of which a considerable area of bone can be laid bare.

The destruction of bone in syphilis of the skull is either the result of a syphilitic infiltration which goes on to caries, or healthy sclerotic portions may become necrotic after destruction of the periosteum. The syphilitic sequestra thus formed are cast off very slowly.

The bone, however, in syphilis of the skull is not always destroyed, but, on the contrary, the new formation of bone sometimes predominates, giving rise to a circumscribed or more diffuse thickening of the bone. This ossifying periostitis and osteomyelitis is usually found in conjunction with gummata, but in rarer cases it occurs alone and may lead to the formation of diffuse warty exostoses of the cranial bones (see Fig. 46). The formation of ivorylike sclerotic bone is characteristic of syphilis in contrast to tuberculosis.

In the diploë syphilis gives rise to exactly the same primary changes as in the periosteum. Much more frequently, however, syphilitic osteomyelitis arises secondarily from the periosteum.

Gummata also occur primarily on the inner surface of the skull between the bone and dura, or within the substance of the dura, or on its inner surface (*pachymeningitis gummosa*), and here seldom undergo a suppurative softening, but are more likely to become caseous. Moreover, exostoses may be formed here with or without gummata. Occasionally syphilitic disease of the endocranium results only in a thickening of the dura, with the formation of strong adhesions between it and the bone, and this is often the cause of the severe headaches which also occur in the ossifying and gummatous forms.

The prognosis of syphilis of the skull is fairly good, and, even though the disease is very extensive, complete healing can be brought about by a suitable general and local antisyphilitic treatment. But the more extensive the disease the worse the prospect of a complete cure, as in such cases syphilis of the internal organs, especially of the brain, is usually present. Death results from general marasmus, waxy degeneration of the abdominal viscera, syphilis of the brain, or suddenly from acute meningitis or sinus thrombosis with pyæmia.

The diagnosis of syphilis of the cranial bones is usually easy to make from the characteristic appearance of the local disease, from the history of the patient, and other symptoms of syphilis which have persisted.

The treatment of syphilis of the skull is constitutional and local, the latter being similar to the treatment of tuberculosis of the skull. The constitutional treatment of syphilis may be successful in every

stage, and consists in the administration of the iodide of potassium or the iodide of sodium (one to two or three grammes a day, and sometimes more) and in the use of mercury, either internally, hypodermatically, or, what is best, in the form of inunctions. (For further particulars of the treatment of syphilis the reader is referred to the Principles of Surgery, § 84.) It is of the greatest importance to keep up the strength of the patient by good air, nourishing food, wine, etc.

As regards the local treatment I refer to what was said about the treatment of tuberculosis of the skull (page 69). I should merely like to warn against too free a use of the chisel in syphilis of the skull; the constitutional antisyphilitic treatment is of more avail. Circumscribed necrotic areas which are cast off very slowly may, for the sake of bringing about more rapid healing, be removed with the chisel.

Necrosis of the Cranial Bones has already been mentioned several times, and it may be well to summarize at this point the most important facts relating to it.

The causes of necrosis are injuries of various sorts, burns, or inflammatory processes, such as cellulitis, suppurative periostitis, tuberculosis, syphilis, etc. When speaking of injuries of the skull we saw that necrosis of the bone may be avoided, even after a very extensive avulsion of the scalp and periosteum, by causing the wound to heal aseptically. If the bone has not completely lost its vitality, owing to the severity of the injury, entirely separated splinters of bone may, as we have already said, heal in place again under aseptic treatment. The chief cause of necrosis is suppuration in the form of a suppurative periostitis, osteomyelitis, and endocranitis. Even when suppuration is already present and the bone is exposed, the necrosis, which has apparently already begun, may often be prevented if the suppuration is terminated quickly enough. It should also be taken into consideration that, although the periosteum may be torn off or become separated by a suppurative periostitis, the cranial bones are very well supplied with blood from the dura mater. In the same way one can understand that after extensive burns of the scalp—for example, in children or epileptics—necrosis may be entirely absent or only superficial in case the wounds run an aseptic course. Deep burns may, however, give rise to very extensive necrosis, which is in part due to the resulting suppuration. Broca reported a case in which three fourths of the vault of the skull became necrotic, exposing in some places the dura. Memel observed a very extensive necrosis which was due to thrombosis of the anterior branch of the middle meningeal artery. For a description of the necrosis resulting from suppuration, tuberculosis, and syphilis of the scalp, the reader is referred to pages 65–72.

The special features of necrosis of the skull are somewhat as follows:

First of all there is the danger of meningitis, sinus thrombosis, or brain abscess from perforation into the cranial cavity, and in this respect necrosis of the skull is the most dangerous of all forms of necrosis of bone. Usually, however, in case of perforation, the necrotic area and the demarcating suppuration become shut off by granulations and adhesions from the rest of the

cranial cavity. It is, moreover, characteristic of necrosis of the skull that no involucrum is formed. If in one place the bone dies in its whole thickness over a considerable area, the defect, except in young individuals, is not closed by newly formed bone, but by a dense connective-tissue cicatrix which is adherent to the dura. It is only exceptionally that defects are covered in by bone in adults. Küster, however, reports a case in which a defect ten centimetres long and eight centimetres wide, in the frontal bone of a woman forty years old, became filled in with bone. Occasionally the necrosis is confined to the inner surface of the skull—for example, after fractures of the skull.

The treatment of necrosis of the skull is, first of all, prophylactic—i. e., the suppuration, which is the chief cause of the same, should be prevented after injuries by antiseptic treatment of the wound, and when present should be limited by prompt incisions and antisepsis. If necrosis is already present, the suppuration must be checked by antiseptic measures. In this way meningitis, sinus thrombosis, and brain abscess are best prevented. If the necrosis is sufficiently localized by a line of demarcation, and the complete separation of the sequestrum is delayed, it is a good plan to remove the latter with the chisel until healthy bleeding bone is reached. All operations for necrosis must be performed with strict attention to asepsis, especially when the bone has to be resected, in order to get at a sequestrum on the inner surface of the skull.

Defects in the cranial bones of appreciable size should be protected by wearing a leather pad or a metal plate, or they may be closed by the transplantation of small pieces of bone or cartilage taken from young animals or children (see Principles of Surgery, § 101), by pedunculated flaps of skin, periosteum, and bone taken from the immediate neighbourhood, or, finally, by decalcified bone plates (Senn) or celluloid plates (Fränkel). The flap of soft parts and bone consists of a portion of the scalp with the periosteum, and a piece of bone of the right size which is chiselled out of the external table. In exceptional cases large defects nine to ten centimetres in circumference have become completely covered in of themselves (Küster, Bruns), and it sometimes seems as though the power of regeneration possessed by the cranial bones were greater than has hitherto been supposed.

Atrophy of the Cranial Bones.—The thickness of the skull varies in different individuals. Atrophy of the cranial bones is either congenital or acquired. Some people have a remarkably thin skull, so that fractures result from very slight injuries. I recently observed a case in which a man twenty years old received a fracture of the base by jumping from his horse. The autopsy showed the skull to be extremely thin and very translucent.

In infants incomplete ossification of the skull (*aplasia cranii*) is sometimes observed which in some cases is found over the entire skull and sometimes is confined to this or that bone. It is probably caused by fœtal rhachitis. In the milder forms of this congenital aplasia there are complete defects in the extremely thin bones, especially in the frontal bone, and in the anterior part of the parietal bone near the sagittal suture (Hofmann, Parrot). In very marked cases small plates of bone, varying in size and as thin as paper, are found lying in large membranous areas formed from the periosteum and dura; these small bony plates send out fine radiating processes into the membranous portions of the skull. After birth, ossification of the skull,

especially in the milder cases, goes on more rapidly, and not infrequently abnormal cranial sutures are formed, which are sometimes present in great numbers (Fig. 47). In the more extreme cases of aplasia the children are otherwise so atrophic that they usually die very soon, especially if placed in unfavourable surroundings.

The causes of the congenital incomplete ossification of the skull or fœtal rhachitis are to be looked for particularly in the mother's poor state of nourishment, in congenital syphilis, or in hydrocephalus.

Fig. 47.—Imperfectly ossified skull (aplasia cranii) made up of numerous small bones (Vrolik).

Incomplete ossification at a particular point of the skull may be caused by tumours, especially dermoids. In this way some of the defects in the skull are to be explained which are found in persons well advanced in life, and are caused by a persistence of the anterior and frontal fontanelles. Frank has reported an interesting case which throws light upon the etiology of congenital defects of the skull. A woman gave birth to three children, all of whom had an indented, unossified area on one side of the forehead, caused by the pressure of a tumour of the promontory of the sacrum upon the child's skull.

The treatment of a congenital circumscribed or more diffuse aplasia of the cranial bones consists, above all, in giving the child proper nourishment, in protecting the soft skull from external injuries, and in removing any tumour of the scalp that may be present (see also page 55, Treatment of Defects of the Skull).

Acquired atrophy of the cranial bones (*atrophia*, seu *anostosis cranii*) may likewise be circumscribed or diffuse, and has many causes, such as inflammatory processes of the periosteum, medulla, and endocranium, tuberculosis, syphilis, aneurisms of the bone, tumours of the scalp, brain, and its membranes, hydrocephalus, etc. In this category belongs also the senile osteoporosis of the cranial bones, which may lead to complete disappearance of the bone—for example, symmetrically—on both parietal eminences. The most common cause of atrophy of the infant's skull is rhachitis, in which there is a formation of imperfect bone, and at the same time increased absorption of already formed bone. It affects particularly the inner surface of the cranial bones, and may cause complete disappearance of bone at various places. The closure of the cranial sutures and the fontanelles is very much delayed in rhachitis. The softness of the bone is particularly marked in the occipital region, owing partly to the fact that the child lies on its back so much of the time, and this soft, impressionable occiput is characteristic of rhachitic atrophy. This hereditary rhachitic atrophy is sometimes caused by syphilis. Since the soft skull readily yields, excessive growth of the cranial contents often takes place, and, on the other hand, when the child lies down, symptoms of pressure on the brain may arise which result sometimes in convulsions. The position of the head should therefore frequently be changed in marked cases of this disease.

Osteomalacia may, in the severest cases, involve the cranial bones, but usually only to a slight extent. Heineke mentions a very unusual case, reported by Kleberg, in which the skull and inferior maxilla of a fifty-three-year-old woman, who died at the end of six months, were found to be the seat of osteomalacia, while all the other bones of the body were normal. Soft, irregular areas, varying in size, were found upon the skull.

The neuroparalytic and trophoneurotic atrophies of bone resulting from diseases of the peripheral nerves and the central nervous system are also of interest.

Finally, it should be mentioned that atrophy of the cranial bones sometimes occurs without any known cause, and may lead to defects, for example, in the squamous portion of the temporal bone, in the occipital region, and in the orbital plate of the frontal bone.

Premature closure of the cranial sutures sometimes occurs in children. In such cases the development of the skull is retarded in a direction at right angles to the synostosed suture (Virchow, Rindfleisch), resulting in abnormal length of the head or the reverse. In spite of this disturbed growth, the development of the brain may go on normally. Microcephalus—i. e., the formation of an abnormally small brain—is essentially a malformation of the brain; the latter remains abnormally small because there is too little brain matter there, and not because the cranial sutures ossify too early. For this reason craniectomy (see page 152) for microcephalus is in the majority of cases an unjustifiable operation.

The treatment of acquired atrophy varies according to the underlying cause. For the treatment of atrophy due to rhachitis and osteomalacia the reader is referred to §§ 108 and 109 of the Principles of Surgery.

Hypertrophy of the Cranial Bones is either confined to a certain circumscribed area, as in the formation of exostoses on the outer and inner tables (see Fig. 34), or there is a more diffuse increase in the volume of the bone.

Hypertrophy of the cranial bones has also been divided into the concentric and eccentric forms. Concentric hypertrophy of the bone includes osteosclerosis and eburnation—i. e., the formation of very compact bone, which occurs especially in syphilis.

Eccentric hypertrophy of the cranial bones, or hyperostosis, results in a real thickening of the bone by the formation of fresh layers and is usually combined with a diffuse sclerosis. It results in the formation of circumscribed osteophytes and bony tumours (osteomata, exostoses), or is spread out diffusely over several or all of the cranial bones. This diffuse hyperostosis may lead to a very great thickening and increase in weight of the cranial bones (so-called elephantiasis ossium). Virchow calls this general hypertrophy of the cranial bones *Leontiasis ossium*. Exostoses of the skull follow certain conditions of irritation in the pericranium and endocranium, particularly in women who have been pregnant. From a collection of seventy-three cases made by Willigk at the Pathological Institute at Prague, all but one were women. Among the seventy-two women forty-seven had been pregnant.

Symptoms of cerebral disturbance are particularly likely to be caused by circumscribed or diffuse hyperostosis in case the tumours, by their growth into the cranial cavity, diminish the amount of room within the latter.

Symptoms of acute compression do not, however, result, as the brain accommodates itself to the gradually increasing diminution of space by a corresponding atrophy and a decrease in the amount of cerebro-spinal fluid. The cerebral manifestations thus caused consist of headache, vertigo, increasing dementia, and often convulsions. Especially in diffuse general hyperostosis of the skull the patients usually die early, as the result of an increasing atrophy of the brain.

Treatment of hypertrophy of the cranial bones is only possible in the case of circumscribed hyperostosis with the formation of osteomata and exostoses (see pages 78–84, Tumours of the Skull), but there is none for the diffuse variety.

Aneurisms of the Cranial Bones.—Among aneurisms of bone, those of the cranial bones are the most frequent. The dilatations of the arteries which run in the canals of the bones increase very slowly and gradually cause the bone to disappear, so that corresponding defects ensue which may involve the entire thickness of the bone. Aneurisms of the cranial bones are usually multiple, occurring in different parts of the skull, and after breaking through externally beneath the scalp form elastic nodular tumours which pulsate (see Fig. 48). In the early stages the thin, bony covering bulges outward and often crackles under pressure. These soft, fluctuating tumours can be emptied by pressure; they remain empty if the common carotid on that side is compressed and become filled again as soon as the compression ceases. In some cases cerebral symptoms are observed if the skull becomes perforated and the tumours project into the cranial cavity.

FIG. 48.—Aneurisms of the cranial bones.

The prognosis in advanced cases of multiple aneurisms, which cover a considerable area, is unfavourable; they usually increase in size, and sooner or later the patients die from rupture of the aneurisms externally, or more commonly into the cranial cavity, from brain disturbances or from increasing marasmus.

Operative treatment, consisting in resection of a portion of the skull, is only possible so long as the aneurisms are circumscribed and not multiple. Bandages which exert pressure and digital compression are, as a rule, not well borne. In advanced cases the treatment consists merely in protecting the tumours from external injury and keeping up the patient's strength by nourishing food.

In this connection may be mentioned the very rare aneurisms of the middle meningeal artery. Heineke mentions, in his excellent work on diseases of the head, seven cases which were, however, in part not carefully observed. As far as may be learned from the cases that have occurred, aneurisms of the middle meningeal artery gradually erode their way through the bone and become recognisable in the form of a fluctuating tumour beneath the scalp. Pulsation is apparently not easy to make out in every case, as the aneurism has often been mistaken for a sebaceous cyst. But it is characteristic that the tumour can be made to disappear, partly at least on pressure, and by compressing the common carotid artery on that side, and a corresponding gap in the bone is then felt. The chief cause of the aneurism is to be looked for in injuries to the middle meningeal artery, especially slight tears in the arterial wall. It may prove fatal from perforation externally or internally, or from increasing functional disturbances of the brain.

The treatment of aneurism of the middle meningeal artery consists, in the first place, in the use of digital compression of the common carotid artery, by means of which Consolini is said to have brought about a cure. If possible, compression of the aneurism should be employed at the same time. Ligation of the common carotid artery is more reliable than compression, but more dangerous and not always successful.

The surest method is that of exposing the middle meningeal artery by resection of the overlying bone with the chisel, ligating the artery at points proximal and distal to the aneurism, and extirpating or slitting open the sac. It is only when the aneurism is situated at the lower portion of the artery, and hence is hard to get at, that Heincke recommends ligation of the common carotid.

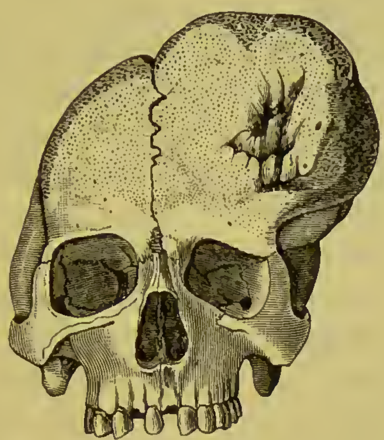
Tumours of the Cranial Bones.—*Enchondromata* of the cranial bones are usually found at the base of the skull. Their favourite location is the ethmoid bone, and from here they grow toward the frontal sinuses, the orbit, or the nasal cavity, and change into osteomata. The frequent occurrence of enchondroma of the ethmoid bone may be explained from the fact that remnants of cartilage persist here for a comparatively long time.

Osteomata of the cranial bone usually originate in the periosteum or in the endocranium on the inner surface of the skull, and are really exostoses, the so-called enostoses which start from the diploë being less common. Osteomata are often the result of a localized irritation of the bone, such as occurs, for example, in injuries, inflammatory processes, or in tuberculosis or syphilis of the cranial bones.

Osteomata occur either in the form of sessile or pedunculated tumours, with a smooth or nodular surface. They are either spongy in

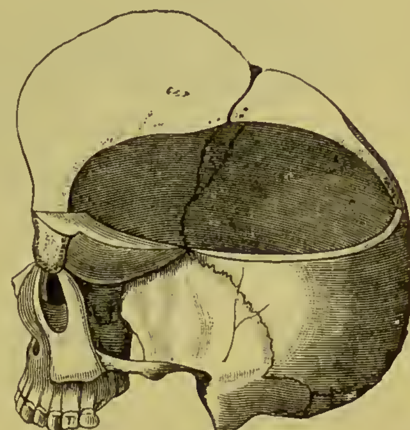
structure or ivory-hard; the older they are the harder their consistency. Cartilaginous areas are most common in osteomata of short standing.

Periosteal osteomata may reach a very large size without encroaching upon the cranial cavity (Fig. 49, *A* and *B*). In other cases osteomata grow simultaneously toward the outer and inner surface of the



A

Fig. 49 *A*.—Periosteal osteoma of the skull (H. Fischer).



B

Fig. 49 *B*. — Longitudinal section of *A*.

bone, as in Fig. 50. Two exostoses confined to the inner surface of the skull are shown in Fig. 51. Exostoses of the inner surface of the cranial bones may likewise attain a considerable size without causing cerebral disturbances. As regards the appearance of certain focal symptoms on the part of the brain, and paralyses of nerve trunks within the cranial cavity—for example, of the optic or olfactory

Fig. 50.—Two exostoses growing both externally and into the cranial cavity (Bardeleben).

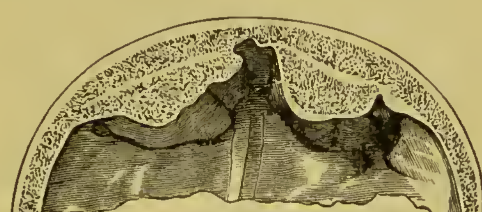


Fig. 51.—Exostoses of the inner surface of the skull (Bardeleben).

nerves—the location of the endocranial osteomata is of importance. Acute compression does not, however, result from such slowly growing endocranial tumours. The most common form of osteoma is the above-mentioned ossified enchondroma of the ethmoid bone which grows toward the orbit, the frontal sinuses, and the nasal cavity.

External exostoses sometimes undergo a partial necrosis, owing to ulceration of the external soft parts, or they may become entirely cast

off. Exostoses of the upper border of the orbit may cause, by diminution of the space within the orbit, exophthalmos, compression of the bulb, and gradual blindness. They may also grow downward in front of the eye, and in this way interfere with the sight.

The diagnosis of osteomata is usually easy to make from their shape and consistency. There are, however, medullary sarcomata of the cranial bones which have an outer shell of bone and are soft inside. In such cases the correct diagnosis can only be made by puncture with a stout hypodermic needle or a drill, or at the time of operation. Osteomata of the inner surface of the skull can only be diagnosticated with any probability when they cause corresponding functional disturbances of the brain or the intracranial nerve trunks.

The treatment of external osteomata consists in chiselling them away after separating the soft parts. In case of ivory-hard osteomata, the chiselling process is very tedious and, on account of possible concussion of the brain and the formation of fissures, not without danger, and hence it is often preferable to saw them off. Internal osteomata, which cause functional disturbances of the brain or the intracranial nerve trunks, should, if possible, be removed by resecting the portion of skull in question. The same measures are adopted in the case of exostoses which have grown both outwardly and toward the cranial cavity. Exostoses of the nasal cavity and frontal sinuses are removed after opening these cavities (see Diseases of the Nasal Cavity and Frontal Sinuses).

Sarcomata of the cranial bones develop either in the periosteum or the diploë, and very frequently follow injuries or arise secondarily by metastasis from other parts of the body. All the different forms of sarcoma are found on the cranial bones, especially the spindle-celled and round-celled varieties, with or without giant cells. Moreover, myxosarcomata, cystosarcomata, and very vascular pulsating sarcomata are found in this region. The softer the sarcoma and the more abundant its cells, the more unfavourable is its course. The most malignant kind are the medullary sarcomata, which upon section have the appearance of brain tissue. Bryk observed a large telangiectatic cystic myxosarcoma of the skull in a peasant woman forty years old (Fig. 52). The tumour grew slowly at first, then more quickly, and after it had lasted two years death resulted from hæmorrhage.

Periosteal sarcomata grow principally outward, but at the same time inward, as well, toward the cranial cavity. In the basal portions of the tumour, where it is joined to the bone, a very marked growth of bone often takes place, and bony processes run out into the soft parts of the tumour (osteosarcoma).

Periosteal sarcomata also include the chloroma—i. e., a light yellow, grass-green, or brownish-green, round-celled sarcoma, which, as far as is known, develops in the periosteum of the bones of the face and cranium, and gives rise to metastasic tumours of the same colour in different organs, especially in the liver and kidneys. According to Huber, the green colour is due to small, strongly refractive granules in the cells, which, as Ziegler and Chiari also state, give the micro-chemical reaction of fat. Chloromata are further characterized by an abnormally large percentage of chlorine (Behring, Wicherkiewitz).

Fig. 52.—Telangiectatic cystoid myxosarcoma of the cranial bones (Bryk).

Medullary sarcomata of the cranial bones have at first a bony envelope which surrounds them completely. They are frequently the seat of excessive osteophyte formation.

Both periosteal and medullary sarcomata, as the bone becomes more and more destroyed grow progressively softer, so that the defect in the bone becomes finally filled with soft tumour masses. After the skin has been broken through, an ulcerating tumour-mass results, occasionally with considerable sloughing. They usually grow inward as far as the dura mater, which they displace together with the brain, or the former is likewise destroyed. They occasionally reach an enormous size, and not infrequently spread to the orbit or the face, and secondary nodules often make their appearance on different parts of the skull or of the body. They sometimes run a very rapid course, and death may occur in eight to ten months, with the formation of metastases in different parts of the body.

Fig. 53.—Formation of bone in a sarcoma of the cranial bones (osteosarcoma) (Pathological Institute at Leipsic).

In connection with sarcoma of the bone the so-called fungus duræ matris may be mentioned here. The term fungus of the dura mater

is an undesirable one, as the tumour is probably always a sarcoma, which starts from the outer surface of the dura and causes a comparatively rapid absorption of the bone. The dura may remain comparatively intact for a considerable time, and the surface of the brain is, as a rule, merely displaced.

The tumour which bulges outward through the defect in the bone at first transmits the pulsations of the brain, but later on the pulsations cease because the tumour becomes adherent to the bone, or rather the latter itself becomes involved. Very often the tumour does not protrude through one large defect in the bone, but through several smaller ones, as in the case shown in Fig. 54. These sarcomata of the dura sometimes work their way out through one of the normal openings, such as the sphenoidal fissure. Their favourite location is the parietal region. The tumour may have already reached a considerable size externally and perforated the skin, while inside the skull but little tumour tissue is found, and in fact the dura may still be intact, as in the case shown in Fig. 54 and in one reported by Heineke. The tumour sometimes reaches an enormous size. Volkmann, for example, reported a tumour which hung down from one side of the head as far as the supraclavicular fossa, and afterward as far as the forearm. Sarcomata of the dura appear to give rise to metastases less often than sarcomata of the cranial bones.

Fig. 54.—Spindle-celled sarcoma of the dura mater (fungus duræ matris) in a young man of nineteen (Bartholomae).

Microscopically, sarcomata of the dura are most commonly of the spindle-celled variety, or very malignant medullary sarcomata or myxosarcomata. They are noticeably frequent in young persons, as is indicated in the two illustrated cases.

The clinical manifestations of sarcomata of bone and of the dura are essentially the same. In both the tumours may have already reached a considerable size, while the disturbances that have been caused are trivial. Their duration until the fatal end is reached is very variable; sometimes their course extends over several years, while in other cases they prove fatal at the end of six months. Death results from increasing marasmus, due, for example, to sloughing of the tumour

after it has broken through the skin, or from hæmorrhage, meningitis, encephalitis, or finally from increasing compression of the brain or paralysis of certain parts of the brain. The prognosis is very unfavourable.

Fig. 55.—Myxosarcoma of the dura mater in a man twenty-eight years old (Heincke).

The differential diagnosis between a sarcoma of the cranial bones and of the dura is usually possible only at the outset. Tumours of the dura are often reducible at first and pulsate, but both of these symptoms are absent after the tumour, as in Fig. 54, has perforated the skull through the enlarged foramina. Excessive ossification at the base of the tumour speaks for sarcoma of the bone, as it is usually not present in a sarcoma of the dura. Medullary sarcomata of bone are usually at the beginning inclosed in a bony capsule. For the differential diagnosis between very vascular pulsating sarcomata and aneurisms the reader is referred to a description of the latter (page 77). The absence of cerebral symptoms should never be taken as a proof that the tumour has not broken through into the cranial cavity.

The treatment of sarcomata of the cranial bones and of the dura consists in their earliest possible extirpation by the resection of a corresponding portion of the bone, using at first the chisel and later on the bone-cutting forceps. In chiselling away the bone, one must avoid shaking up the brain, as this may cause serious symptoms of concussion, as is shown by the experiments made by W. Koch and Filehne. In many cases the portion of the tumour lying on top of the bone must be removed before the skull is resected. In tumours of the dura a sufficiently large piece of the latter is excised. If it is found that the tumour is adherent to the other membranes of the brain, a thorough removal is hardly possible. Often enough a radical operation is impracticable, owing to the great size of the tumour or to secondary nodules, although we can at present accomplish, with the aid of antisepsis, much more than before.

By means of a strictly aseptic operation we can also prevent meningitis, from which, at one time, most patients who were operated upon died. Volkmann lost a patient with sarcoma of the dura from the entrance of air into the superior longitudinal sinus. In order to prevent this accident after the sinus has been opened during the operation, Genzmer recommends the following measures: Deep, regular narcosis, avoidance of forced inspirations, and irrigation with some indifferent fluid with which the open sinus should be covered. It is probably best

to follow Heineke's advice and first pass two ligatures around that portion of the sinus which will have to be opened, and then divide it between the ligatures. I am also inclined to doubt with Heineke whether a radical operation should be performed in cases where the superior longitudinal sinus has to be divided. Most operations for sarcoma of the dura remain unfinished. Heineke mentions only a very limited number of cures, those from older literature being the cases of Hauser and Pecchioli, and from more recent literature those of Billroth, Novaro, Langenbeck, and E. Küster.

Echinococcus Cysts of the Cranial Bones are very rare. Heineke mentions three cases. The cyst usually grows outward through the bone from within the cranial cavity. The diagnosis is only possible when the echinococcus cyst lies beneath the scalp, and some of the characteristic contents (scolices, hooklets, and portions of the membrane) can be evacuated by means of a hypodermic syringe and examined microscopically. (For a more detailed description of echinococcus cysts see § 161, Echinococcus Cysts of the Liver.)

Echinococcus cysts have also been observed within the cranial cavity, in which case the prognosis is very bad. They can, of course, only be diagnosed when the cyst has perforated the cranium and comes to lie beneath the scalp.

The treatment of echinococcus cysts of the cranial bones consists in incising and emptying the cyst after scraping away and chiselling out the affected bone. In case the cyst communicates with the cranial cavity, it should first be exposed by resecting enough of the bone, and then opened in the same way and scraped out.

CHAPTER III.

INJURIES AND DISEASES OF THE BRAIN AND ITS ADNEXA.

GENERAL REMARKS UPON THE ANATOMY AND PHYSIOLOGY OF THE BRAIN.

Injuries: Concussion of the brain (commotio cerebri); compression of the brain (compressio cerebri); injuries to the intracranial blood-vessels.—Aneurisms of the internal carotid artery within the carotid canal.—Injuries to the cranial nerves during their course within the skull.—Injuries to the brain and the medulla.—Prolapse of the brain following traumatism.

Diseases of the brain and its adnexa: Inflammation of the membranes of the brain and the sinuses (dura mater, sinuses, and soft membranes).—Diseases of the brain (abscess, tumours, epilepsy, microcephaly, etc.) and their surgical treatment.—Hydrocephalus.—Hernia of the brain and its membranes (hernia cerebri, cephaloceles).—Trephining.—Temporary or osteoplastic resection of the skull.

Appendix: Injuries and diseases of the frontal sinuses.—Anatomy and embryology.—Injuries: Foreign bodies.—Diseases of the frontal sinuses (catarrh, dropsy, empyema, tumours, etc.).

§ 12. **General Remarks upon the Anatomy and Physiology of the Brain.**—Our knowledge of the anatomy and physiology of the brain has been very much added to in the last few years, and, above all, the important fact has become known that each separate function is intimately connected with a certain portion of the brain. The surgeon must be entirely familiar with these main anatomical and physiological facts, as he is often called upon to treat by operative measures the diseases and injuries of the brain and its adnexa.

Hence it may be well to review the most important facts regarding the anatomy and physiology of the brain in so far as they are of interest to the surgeon.

The Membranes of the Brain.—The inner surface of the skull is lined by the dura mater, which forms the internal periosteum or endocranium. Next to this hard covering come the soft membranes of the brain, which are to be looked upon as loose connective tissue that becomes compacted in the form of a membrane on the surfaces adjoining the dura and the brain. Next to the inner surface of the dura comes the arachnoid membrane, and next to this the vascular pia mater covering the surface of the brain, from which numerous arteries and veins enter the brain. The two membranes last mentioned should be regarded as one, and between them lies the subarachnoid

tissue, which is loose, contains meshes, and may be compared to very œdematous connective tissue. Its meshes are filled with cerebro-spinal fluid.

Between the dura mater and arachnoid is found the subdural space into which blood-vessels, nerves, and Pacchionian bodies—i. e., villous outgrowths of the arachnoid—project. In some places connective-tissue septa are found connecting the dura and arachnoid. The dura and arachnoid, and hence the subdural and subarachnoid spaces as well, are prolonged in the form of a sheath for the nerves that leave the brain and spinal cord (Schwalbe, Retzius). These prolongations of the dura and arachnoid become continuous with the neurilemma of the nerves, while the subdural and subarachnoid spaces pass on into the serous spaces of the peripheral nervous system.

The cerebro-spinal fluid is found principally beneath the arachnoid and in the ventricles of the brain; the subdural space contains but a very small amount of fluid. The arrangement of the cerebro-spinal fluid in the subarachnoid space, in the sheaths of the vessels and nerves, and in the ventricles is such that it circulates freely in all these cavities and clefts. The subarachnoid space communicates, by means of the foramen Magendii, on the floor of the fourth ventricle, where the choroid plexus emerges, with the ventricles of the brain. This free communication of the cerebro-spinal fluid within the brain and spinal cord is of great importance for the regulation of the circulation within the skull, and, as we shall see later on, for purposes of compensation in case of intracranial pressure which may occur under pathological conditions such as intracranial hæmorrhage and depressed fractures. The cerebro-spinal fluid has the function of compensating for the variations in the size of the brain resulting from an increase or diminution in its blood supply. If the size of the brain always remained the same, the cerebro-spinal fluid would be unnecessary. The brain, however, moves, as can be easily seen and felt on the anterior fontanelle of a child's skull—i. e., it expands and contracts just like any organ through which blood circulates. It expands at every systole and grows smaller during every diastole. In the same way its amount of blood and its volume changes during inspiration and expiration. The rhythmic upward impulse of the brain, which is synchronous with the systole of the heart, results from the systolic filling of the arteries with blood. The respiratory upward impulse of the brain occurs during expiration, and represents a variation in the amount of blood in the vessels during respiration.

Leyden, Bergmann, and others have made curves from these two kinds of pulsation. According to Leyden, the circulatory pulsations amounted to 0·4 centimetre, and the respiratory to two to three centimetres of a column of water in a barometric tube. Mosso compared the curve of the circulatory movements of the brain with that of a column of water in a reservoir in which the hand was inclosed air-tight, and he persuaded himself of the simultaneous appearance of both pulsating movements in the hand and brain. According to Donders and Berlin, the brain expands and contracts only in case the skull is open, but not when the skull is entirely closed. Althann, Duret, and others have shown, however, that the curve of the movements of the brain is the same in the open as in the closed skull.

This expansion and contraction of the brain, resulting from the variation in the amount of blood during systole and diastole and during inspiration and expiration, is only made possible by the fact that the freely circulating cerebro-

spinal fluid can pass out of the subarachnoid space of the brain into the extra-cranial lymph channels, and especially into the expansible spinal canal. The latter is the chief route by which the cerebro-spinal fluid leaves the skull during the circulatory and respiratory expansion of the brain. The spinal canal is enabled to receive the cerebro-spinal fluid that is pressed out of the cranial cavity because between the dura and the inner wall of the vertebral canal a good-sized space is present which is filled in with easily displaceable fatty tissue. This space sends out processes through the large intervertebral foramina. Moreover, the ligaments of the vertebral canal yield considerably, especially those of the cervical vertebræ, and between the atlas and occipital bone. If at the latter place the membrana obturatoria atlantis postica is exposed in a dog, the bulging out of the same at every systole can be demonstrated.

In case of very much increased intracranial pressure under pathological conditions, the escape of cerebro-spinal fluid is also facilitated by the extra-cranial lymphatics which emerge from the subarachnoid space, and which, according to Arnold, Schwalbe, and others, are found along the internal jugular vein, the carotid artery, and the nerves, especially the optic and olfactory. Moreover, by means of the Pacchionian bodies, cerebro-spinal fluid can flow out of the subarachnoid space into the sinuses. Finally, the venous circulation is favourable for a rapid escape of blood from the cranium. The dural sinuses communicate by means of numerous channels with the veins of the skull, the scalp, and the neck; the sinuses have no valves.

The brain is supplied with arterial blood from its base by means of the anterior, middle, and posterior cerebral arteries. The first two arise from the internal carotid, the latter from the basilar artery which results from the union of the two vertebral arteries. The basilar artery gives rise especially to the arteries for the pons and the cerebellum. The arteries of the cortex anastomose among each other, while those of the large cerebral ganglia are terminal arteries—i. e., they do not anastomose—so that in case the circulation is interrupted in one of the smaller branches, disturbances of nutrition and death of the part of the brain involved result.

The brain is partly a conducting organ and partly an independent organ for motion and sensation. In the gray cortex of the brain are collected at certain definite points, which form the centres of the different functions, all those impulses which result from peripheral or central stimuli. In other words, the cortex serves as a central organ for complex movements and sensations; in it are mirrored all objects of the outer world, and the will of the person is the necessary result of all these expressions and impulses. By practice the individual learns to make these centres of more and more use to him. The different motor and sensory conceptions become collected in the form of definite impressions or "memory-pictures" in the cortex, and we are then able to call up voluntarily these conceptions which are located in definite portions of the surface of the brain and bring them before our consciousness. Within the separate centres of this system substitution

takes place to a certain extent, in that intact ganglion cells and nerve fibres assume the work of others which have been destroyed. This explains in part why it is that injuries to the brain so often cause no symptoms.

If the cerebral cortex is the organ of consciousness and the central organ for complex movements and sensations, the separate portions of this cortex must have a different physiological or functional importance—i. e., there must be centres here for the single sensations and movements. Connected with these motor and sensory centres of the gray cortex there are medullary nerve fibres along which the stimuli from all sensory nerves are carried to the cortex, and there are other fibres along which the centrifugal stimuli of the will are carried to the voluntary muscles.

In fact, we already know such motor and sensory centres in the cortex. In order to locate them it is necessary to have an exact knowledge of the topography of the cortex.

Topography of the Cortex.—The external surface of the cerebral hemispheres is divided into four lobes—the frontal, the parietal, the temporal, and the occipital.

The arrangement of the sulci and convolutions of the hemispheres is very variable, but, owing to the arduous labours of able anatomists, we are able to-day to make order out of the apparent confusion. Fig. 56 gives a schematic illustration of the most important sulci and convolutions which are of the greatest significance also for the localization of cerebral lesions. On the frontal lobe of the hemisphere we distinguish the superior and inferior frontal sulci, and the first, second, and third frontal convolutions (see Fig. 56, 1, 2, 3).

Next to the posterior portion of the first frontal convolution on the inner surface of the hemisphere above the anterior central convolution is the paracentral lobule. This paracentral lobule results from the junction of the anterior and posterior central convolutions—i. e., the latter pass inward over the border of the hemisphere and in the vicinity of the posterior portion of the first frontal convolution join together to form the paracentral lobule.

Between the frontal and parietal lobes commences the fissure of Sylvius, which divides into two branches—a short anterior or ascending limb two to three centimetres in length, and a posterior or horizontal limb five to six times as long.

The wedge-shaped portion which is included between the two limbs of the fissure of Sylvius is called the operculum.

In the parietal lobe the central fissure, or fissure of Rolando, is particularly noticeable. It begins above the long horizontal limb of the

fissure of Sylvius, sometimes very close to it, and passes upward toward the free margin of the hemisphere. In front of and behind the fissure of Rolando are situated the anterior and posterior central convolutions (see Fig. 56, 4 and 5). The fissure of Rolando and these two convolutions are very easy to make out. Here is found the motor area for the upper and lower extremities, the centre for the hypoglossal

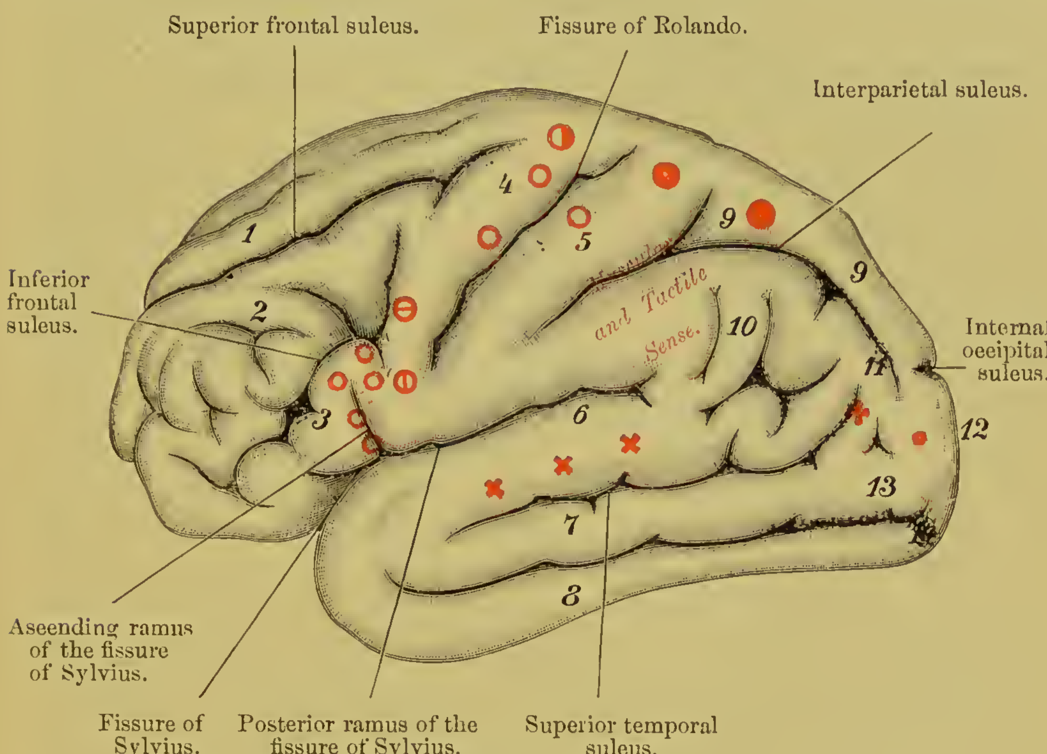


Fig. 56.—Schematic representation of the cerebral cortex and its centres.

1. First.
2. Second. } Frontal convolution.
3. Third.
4. Anterior.
5. Posterior. } Central convolution.
6. Upper.
7. Middle. } Temporal convolution.
8. Lower.
9. Upper.
10. Lower. } Parietal convolution.
11. Gyrus angularis.
12. Upper.
13. Middle. } Occipital convolution.
14. Lower.

○ In 4 and 5 on both sides of the fissure of Rolando, motor area for the upper extremity.

◑ Motor area partly for the upper and partly for the lower extremity (great toe).

● Motor area for the lower extremity.

⦶ Cortical area for the hypoglossal nerve.

⊖ Cortical area for the facial nerve.

o (3) Motor aphasia.

✕ (6) Sensory (auditory) aphasia with word-deafness.

+ (11) Aphasia with word-blindness.

• (12) Region of the visual area (see also Fig. 57).

and facial nerves, and in part the centre for dermal and muscular sensation. Both of these convolutions are about equal in width; the anterior one becomes continuous in front and below with the three frontal convolutions, while the posterior one is bounded behind by the interparietal sulcus. Below, just above the fissure of Sylvius, the two run into one another.

Below the fissure of Sylvius, and more or less parallel to its horizontal limb, is found the superior temporal sulcus (Fig. 56), which commences about one centimetre below the beginning of the horizontal limb and runs backward farther than the latter to the interparietal sulcus.

Between the superior temporal sulcus and the fissure of Sylvius the superior temporal convolution is situated, which is of great importance in connection with aphasia (Fig. 56, 6). Besides this, we distinguish on the temporal lobe the middle and inferior temporal convolutions (Fig. 56, 7 and 8).

The posterior boundary of the posterior central convolution is formed by the interparietal or parietal sulcus just mentioned (Fig. 56). It begins above the horizontal limb of the fissure of Sylvius at a varying distance from it and from one and a half to two centimetres behind the beginning of the fissure of Rolando. From here it runs at first almost parallel to the latter and then divides usually on a level with the centre of the same into a curved limb running backward, and a shorter limb which passes forward and upward more or less parallel to the fissure of Rolando. In the vicinity of the interparietal sulcus is situated the motor area for the lower extremity, and on both sides of it and farther backward the centre for dermal and muscular sensation. Above and below the interparietal sulcus are found the superior and inferior parietal convolutions (Fig. 56, 9 and 10). The inferior parietal convolution consists of two portions, an anterior and a posterior, the former becoming continuous with the superior temporal convolution, while the latter curves around the posterior extremity of the superior temporal sulcus and becomes continuous with the middle temporal convolution. This posterior portion of the inferior parietal convolution, which is of great importance in connection with aphasia, and particularly sensory aphasia with word-blindness, is also called the angular convolution (see Fig. 56, 11). In the region of the interparietal sulcus we find a very large number of variations.

On the occipital lobe the calcarine fissure is of special importance because in its vicinity the centre for vision (Fig. 57) is situated. The calcarine fissure begins with the parieto-occipital fissure close behind the splenium of the corpus callosum, and both diverge in such a way that the parieto-occipital fissure ascends more vertically and appears as a deep groove on the inner margin of the hemisphere (Fig. 57, *F.po.*). The calcarine fissure runs backward toward the posterior extremity of the hemisphere and reaches the same near its under surface (Fig. 57). The portion of brain substance included between the calcarine fissure and the parieto-occipital fissure is called the cuneus. The most pos-

terior portion of the parietal lobe in front of the cuneus on the inner surface of the hemisphere is called the precuneus (Fig. 57, *P*).

On the occipital lobe we distinguish externally the superior, middle, and inferior occipital convolutions (Fig. 56, 12, 13, 14), the boundaries

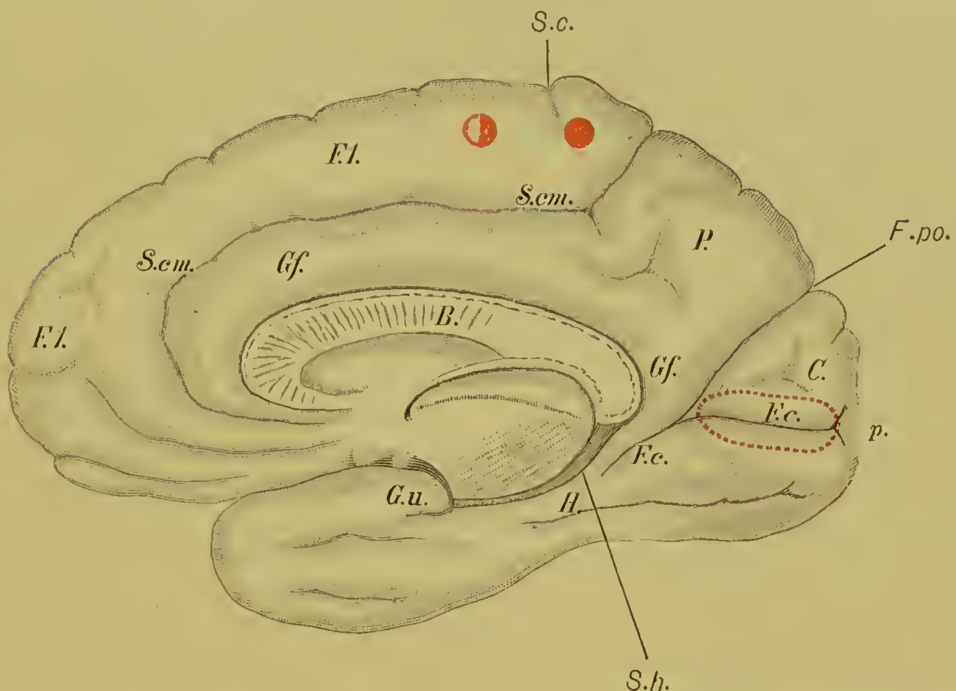


FIG. 57.—View of the right cerebral hemisphere from the median side: *B*, corpus callosum divided longitudinally; *G.f.*, gyrus fornicatus; *H*, gyrus hippocampi; *S.h.*, sulcus hippocampi; *G.u.*, gyrus uncinatus; *S.c.m.*, sulcus calloso-marginalis; *F.1*, first frontal convolution; *S.c.*, termination of the fissure of Rolando; in front the anterior central convolution with the motor area partly for the upper and partly for the lower extremity, and behind the posterior central convolution with the motor area for the lower extremity; *P*, præcuneus; *C*, cuneus; *F.po.*, parieto-occipital sulcus; *p*, polus; *F.c.*, calcarine fissure; in the posterior part of this the visual area is shown by a red dotted line.

of which are very variable. The middle and inferior occipital convolutions are usually continuous with the middle and inferior temporal convolutions.

Localization of the Cortical Areas.—In the cortex which has been thus roughly sketched the following localized areas are known and are represented schematically in Fig. 56. I will only remark that I have inserted only those areas which have been demonstrated beyond a doubt. The portions of the brain which are marked correspond to those points in the cortex where the area in question is sure to be found. The extent of the different areas of localization and their limits as regards one another are not given in Fig. 56, because such an exact representation is not possible at the present stage of our knowledge.

In the localization of diseases of the brain, Broca, Meynert, Hitzig,

Fritsch, Flechsig, Munk, Nothnagel, Naunyn, Charcot, and others have won much credit.

The motor areas of the cerebral cortex were first discovered by Fritsch and Hitzig, who showed that by electrical stimulation of a certain portion of the cortex in the vicinity of the anterior and posterior central convolutions and the superior parietal convolution in the dog, movements of certain groups of muscles take place on the opposite side of the body. If the stimulation is continued for some time or gradually increased, the muscular contractions spread, cross over to the other side, and may result finally in general convulsions.

In accordance with these experimental results, which were also confirmed by Munk, Goltz, and others, it has been observed that in man also irritation of these cortical areas due to injuries brings on epileptiform contractions and convulsive movements in certain groups of muscles on the opposite side of the body, which may give place finally to general convulsions.

These movements of certain groups of muscles resulting from the electrical stimulation of a certain area in the gray cortex of the brain were all the more surprising because the fact was known that the gray matter of the spinal cord is not susceptible to direct stimulation. As C. Ludwig and Fick showed, the white matter of the anterior and posterior columns of the spinal cord can be directly stimulated while the gray can not, although the latter is able to transmit the stimuli in every direction (Schiff).

The above-mentioned region of the cortex in the neighbourhood of the fissure of Rolando was hence called the motor area. Furthermore, the interesting fact was established that after removal of the motor area in certain animals, such as the dog, complete or permanent paralysis of the muscles in question did not occur, as might be expected, but only a transitory or permanent disturbance of the muscular sense and impairment of volition. Munk was of the opinion that the removal of this region caused a loss of memory-images of the tactile, pressure, and muscular sensations—in other words, that the same is in reality a sensory region. Munk therefore called it the "feeling sphere" (*Fühlsphäre*), and the conceptions arising in it were thought to be the cause of the so-called voluntary movements. Motor paralyses were thought by him to take place only when the cortex loses its power of receiving sensory impulses—i. e., when the conceptions of touch, position, pressure, and movement, as stimuli to the carrying out of movements, are absent. Man and the different animals react very differently to lesions of the cortex. In the case of frogs and pigeons the hemispheres can be removed without seriously impairing the power of locomotion. The brain of the Guinea-pig and the rabbit are more sensitive; next in the scale comes the dog, the monkey, and finally man. In man lesions of the cortex give rise to very complete paralyses.

The most recent investigations relating to Hitzig's motor area and Munk's "feeling sphere" show that the two are not identical, that they are separable, but that they lie in close proximity to one another. Circumscribed injuries of either of the centres give rise to isolated motor paralyses or paralysis of muscular and tactile sensation (ataxia, disturbances of co-ordination) in the sense in which Munk meant it.

According to the latest investigations, we know of the following motor areas on the cortex of the hemispheres :

At the lowest part of the anterior central convolution near the centre for motor speech lie the centres for the facial and hypoglossal nerves (see Fig. 56 ⊖ ⦶).

In the middle portion of both central convolutions on each side of the middle of the fissure of Rolando is situated the motor area for the upper extremity (see Fig. 56 ○ 4, 5). The motor area for the lower extremity lies in the upper or median portion, principally of the posterior central convolution, extending as far as the superior parietal convolution (see Figs. 56 and 57, ●). In the upper or median portion of the anterior central convolution—in other words, in the paracentral lobule—the motor areas for the upper and lower extremity merge into one another, and both extremities can be paralyzed by lesions at this point (see Fig. 56 and Fig. 57 ◑).

The centre for tactile and muscular sensation may be located, according to the latest observations, in that portion of the cortex where it is marked in Fig. 56—i. e., on both sides of the interparietal sulcus. This area corresponds in general to Munk's "feeling sphere." Lesions of this portion of the cortex give rise to paralysis of muscular and tactile sensation, sometimes as paralysis of the muscular sense, which shows itself in the form of ataxia or disturbances of co-ordination, and sometimes as a disturbance of sensation in the skin (increase or diminution of the same), with or without motor disturbances.

By ataxia is understood, as is well known, that condition in which the co-ordination of the muscles or groups of muscles required in carrying out some voluntary movement is disturbed while the function and strength of the single muscles may be perfectly normal. Besides this cortical ataxia we distinguish a spinal, bulbar, and cerebral ataxia in diseases of the spinal cord, the medulla oblongata, and the cerebellum.

The speech centres in the cortex are of special interest. According to Naunyn, we know at present of three different centres for speech, two being sensory and one motor. The motor speech centre for word-formation lies, as Broca first discovered, in the third frontal convolution, very near the centre for the muscles of speech—i. e., for the facial and hypoglossal nerves (see Fig. 56, 3 ○). Lesions of this third frontal convolution give rise to motor aphasia, in which the patient, in spite of being entirely conscious and having a completely movable tongue, can not talk, because he has lost the word-forming-power—i. e., the conception of the movements required in speaking.

The second speech-centre in the cortex is situated, according to Wernicke and Naunyn, in the posterior two thirds of the superior temporal convolution, where it is highly probable that the centre for auditory perceptions is located (see Fig. 56, 6 × × ×). Lesions of this portion of the cortex give rise to so-called sensory aphasia with word-deafness (Wernicke), in which the patients have lost the memory of the sound of words, so that they do not understand words—in fact, are word-deaf, although their hearing is completely normal.

The third speech-centre lies, according to Naunyn, in the neighbourhood of the centre for vision in the most posterior portion of the angular convolution where it merges into the occipital lobe (see Fig. 56, 11 +). A lesion of this area causes sensory aphasia with word-blindness in which the comprehension

of letters is disturbed, although here also the visual sense as such is normal in the same way that in aphasia with word-deafness the sense of hearing as such is not disturbed.

The visual centre is situated in the occipital lobe, principally in the vicinity of the calcarine fissure (see Fig. 57). The disturbances of vision which have been observed to follow lesions of the above centre are, according to Nothnagel, the following: 1. Hemianopia. 2. Total blindness. 3. Color-blindness. 4. Mind-blindness. 5. Subjective sensations of light and visual pictures. (For more exact details see page 124, Injuries of the Brain.)

If the prefrontal portion of the frontal lobe is removed in dogs or monkeys the following psychic disturbances are observed: They become excited, run about aimlessly, are indifferent to everything, become ravenous, and show a diminution in sexual appetite (Bianchi). The centre for smell has been located in the gyrus hippocampi on the under surface of the hemispheres.

Flechsig's new investigations are of great importance as regards the problem of the mental activity within the brain or in its cortex. He found in the cerebral cortex four connecting areas which have an identical anatomical structure differing from that of the other portions of the cortex. These four centres lie in the frontal lobe, the temporal lobe, the posterior part of the parietal lobe, and the island of Reil. It is the extraordinary development of the above centres that distinguishes the human brain from that of the animal. Flechsig calls them mental or association centres, because they join together the activities of the different organs of sense to higher units. They are not present in the infant, but it is only after months, when the rest of the brain substance has developed medullary fibres, that these centres with which the child is to think begin to develop. The association centres are connected with one another by numerous systems of nerve fibres. The centres for the special senses (vision, hearing, smell, touch, etc.) represent, as compared with the association centres, inferior units; they receive the impulses coming from the sense organs, but the contents of these impulses are not changed into thoughts until they have reached the association centres which are connected by innumerable fibres with the sense-centres. The activity of the centres of special sense is directed outward, that of the centres of association inward. The latter form the mental bond of the sense-centres, they work over the impulses reaching the same, and are the seat of experience, knowledge, perception, speech, and all the higher feelings. The importance of the mental centres is best shown in the newborn child; their development begins after the completion of the inner construction of the centres for the special senses, at the end of the third month. This is brought about by the growth of more and more numerous nerve fibres from the sense-centres into these new areas, which terminate close together in the cortex. About two thirds of the entire cortex serve the higher functions of the centres of association. The organ of the human mind is composed of the centres for the special senses and the centres of association; like the former, the latter have not all the same relative importance. Complicated mental performances require the combined action of all four association centres, but pathological experience shows that one centre may remain intact while another is disturbed; speech may, for ex-

ample, be confused while the perception of the outer world is unchanged, and *vice versa*. The ability to express one's knowledge by means of speech is clearly not associated with the same centre with the ability to grasp the natural relation of things.

The Cerebral Ganglia, Cerebellum, and Medulla.—Of the cerebral ganglia I shall mention first the corpus striatum.

Destruction of the corpus striatum gives rise to motor paralysis of the opposite extremity. Softening of the nucleus caudatus and lentiformis may, however, cause no symptoms (Charcot, see also Injuries of the Brain, page 126).

The function of the optic thalamus is still very obscure. On account of its anatomical relations it probably has something to do with vision. It may possibly be an important centre for the different reflexes. It is still doubtful whether the motor symptoms of irritation (tremor, athetosis), observed after destruction of the optic thalami, are dependent upon them.

The corpora quadrigemina stand in direct relation to the optic nerve and the movements of the eyes (third, fourth, and sixth cranial nerves). (See also page 126, Injuries of the Brain.)

Injury to the crura cerebri causes paralysis of the nerves of the extremities—the hypoglossal, the facial, and the trigeminal on the opposite side of the body, besides paralysis of the branches of the third on the same side.

Lesions of the pons give rise to crossed motor and sensory paralyses of the extremities, while the fifth, sixth, seventh, and twelfth nerves on the same side may be paralyzed.

The cerebellum is the centre for co-ordination. Injury to this portion of the brain in man causes ataxia (especially after injury to the vermiform processes) and disturbances of equilibrium (vertigo, a reeling, staggering gait, revolutions on the long axis of the body).

In the medulla oblongata, the continuation of the spinal cord, very important centres are found, especially the respiratory and vaso-motor centres.

The respiratory centre is situated in the formatio reticularis, corresponding to the apex of the calamus scriptorius, on a level with the ala cinerea and below the vaso-motor centre. This centre is influenced by the will, the amount of gas in the blood, and by irritation of the sensory nerves, especially the pneumogastric.

The vaso-motor centre is also situated in the formatio reticularis, on the border between the pons and medulla (Ludwig). This centre can likewise be brought into activity by stimulation of certain portions of the central nervous system and of the peripheral nerves, so that contraction or dilatation of the blood-vessels ensues.

Another centre in the medulla is the inhibitory centre of the heart, from which the activity of the heart can be inhibited along the course of the pneumogastric (Weber).

As in the spinal cord, there are centres in the medulla which institute reflex movements by means of the nerves which enter and leave them. Of these the most important are the centres for mastication, deglutition, closing the eyelids, sneezing, and coughing

Finally, it should be mentioned that after injury of a certain part of the fourth ventricle at the apex of the calamus scriptorius, transitory diabetes ensues (Bernard's "*piqûre*"). This does not take place if the splanchnic

nerves are previously divided. Injury to a circumscribed spot below the diabetic centre gives rise, according to Bernard, to polyuria without sugar in the urine (diabetes insipidus), while a puncture somewhat above the diabetic centre causes albuminuria with a normal amount of urine. Moreover, injuries to the cerebellum and the spinal cord, especially complete division of the latter (Schiff), division of the upper thoracic and lower cervical ganglia of the sympathetic (Pavy), irritation of the depressor nerve (Filehne), and central irritation of the pneumogastric may cause sugar to appear in the urine.

Microscopic Anatomy of the Brain and Medulla.—Meynert and Flechsig in particular deserve great credit for their work on the microscopic anatomy of the brain, and the course of the fibres in this and the medulla. We have Flechsig to thank for the latest but most serviceable method of investigation, which depends upon the fact that the fibres of the central nervous system do not receive their medullary sheaths at the same time, but one after the other during a long period of fœtal and extra-uterine life. The fibres of the same origin and course, which have already received their medullary sheaths, may be differentiated from all non-medullary fibres by staining them with hæmatoxylin (after Weigert), or with the chloride of gold (after Freud).

In the brain, just as in the spinal cord, we distinguish motor (centrifugal) and sensory (centripetal) fibres.

The brain and spinal cord consist of white and gray matter. The gray matter of the spinal cord, which is perforated by the central canal, is surrounded by the white matter. The gray matter of the spinal cord contains the branches and accessory nerve tracts, while the white matter contains the main tracts. The conduction from the brain to the spinal cord takes place only along the main centripetal or sensory tracts and centrifugal or motor tracts, as the connection between the gray matter of the spinal cord and brain is interrupted by white matter. A portion of the gray matter of the spinal cord continues through the fourth ventricle and the aquæductus Sylvii as far as the infundibulum. Within the brain the fibres cross and interlace in the most complex way. The gray matter of the brain contains the ganglionic cells; the white matter, on the other hand, consists only of nerve fibres. The gray ganglionic matter is found within the brain in the fourth ventricle, the optic thalami, the corpus striatum, the nucleus lentiformis, the corpora quadrigemina, the cerebellum, and, above all, in the cortex.

Pathways in the Brain and Medulla.—The course of the fibres within the brain will be but briefly described here. For a more exact description I refer the reader to Flechsig's two works on the subject, Die Leitungs-bahnen im

Gehirn und Rückenmark des Menschen, 1876, and Der Plan des menschlichen Gehirns (Leipsic, Veit & Co., 1883).

The nerve fibres which radiate from the crura and pons toward the cortex are known under the name of the corona radiata.

The fibres of the corona radiata converge to form the crura cerebri. The latter are divided into two portions by the locus niger—the crusta and tegmentum. The tegmentum contains the sensory tracts of the entire surface of the body except the olfactory and the optic nerves, while the crusta contains the motor fibres.

From the cortex of the two central convolutions and the paracentral lobule arises the so-called pyramidal tract, which forms a direct connection between the cortex and the motor nerve roots of the spinal cord. It passes from the above-mentioned portion of the cortex within the corona radiata into the internal capsule, and then through the crura cerebri and the pons into the medulla oblongata. Near the anterior surface of the latter the fibres undergo an incomplete crossing: the mass of the fibres passes over to the opposite side to form the crossed pyramidal tract, while the smaller portion remains uncrossed and continues as the anterior pyramidal tract. They then both enter the gray matter of the anterior horns. In their whole course the pyramidal tracts connect neither with the ganglion cells of the cerebrum nor with those of the pons. The transmission of voluntary impulses to the anterior roots of the cord undoubtedly takes place in the pyramidal tracts. It is, moreover, probable that all motor nuclei are connected with the cortex by means of the fibres of these tracts.

Interruptions of the continuity of the pyramidal tracts at any point always cause paralysis of the opposite side, which, according to the location and extent, may be a hemiplegia or a paralysis of single limbs, such as the arm or leg (monoplegia).

The fibres of the tegmentum include those for tactile and muscular sensation, and for the auditory and gustatory nerves. Some of the fibres pass through the posterior third of the internal capsule, and within the corona radiata to the paracentral lobe of the cortex. The fibres of the tegmentum are re-enforced by fibres which pass from the corpora quadrigemina to the cortex, and by fibres which pass from the nucleus tegmenti through the thalamus opticus to the parietal lobe.

Below, the sensory fibres of the tegmentum pass through the pons to the spinal cord, where they are connected mainly with the posterior and lateral columns, or with the posterior roots.

Among other nerve tracts I mention the one which connects the visual centre in the occipital lobe with the first visual centre in the optic thalami and the corpora quadrigemina.

The thalamus opticus is, moreover, directly connected with all the lobes of the cortex, the corpus striatum, and the crura cerebri.

The corpus striatum sends numerous fibres to the crusta. The nucleus lenticularis receives mainly centripetal fibres from the tegmentum.

Of the connections of the cerebellum with the cerebrum the most important are the anterior and posterior tracts, passing from the cortex and the pons. The former passes from the cortex of the frontal lobe through the internal capsule and crusta to the pons, and from here into the cortex of the

cerebellum (Flechsig). The posterior tract arises in the cortex of the temporal and occipital lobes, and emerges from the pons into the middle portion of the cerebellum.

The tract connecting the corpus striatum, the pons, and the cerebellum arises in the nucleus caudatus and the outer portion of the nucleus lenticularis, and, passing through the crusta and the pons, reaches the cerebellum.

The crura cerebelli superiora have their origin chiefly in the corpus dentatum of the cerebellum, and pass for the most part into the locus niger of the tegmentum.

The connection between the cerebellum and medulla is formed by parts of the corpus restiforme—viz., (1) fibres from the cortex of the vermiform process to the formatio reticularis; (2) fibres from the cortex, principally of the hemispheres, to the olivary body; (3) fibres from the cortex of the vermiform process to the nuclei of the posterior columns; (4) fibres from the nucleus in the roof of the fourth ventricle to Deiter's nucleus; (5) fibres from the spheroidal nucleus and nucleus in the roof of the fourth ventricle to the nucleus of the auditory nerve. The fibres designated as 1, 2, and 3 correspond to the outer portion of the corpus restiforme, the others to the inner portion of the same.

The tracts for the conduction of ascending sensory impulses pass from the periphery upward through the posterior roots of the spinal cord partly into the gray matter and partly directly into the posterior columns. From the gray matter some of the fibres pass crossed, others uncrossed, into the lateral columns. Pain is probably conveyed entirely through the gray matter; sensations of temperature and touch, on the other hand, through the white matter, partly of the posterior and partly of the lateral columns. The sensory tracts become crossed in the spinal cord itself very soon after their entrance through the posterior roots. Within the brain the sensory tracts pass through the tegmentum and the posterior portion of the internal capsule (*carrefour sensitif*) to the cortex, where they terminate below and behind the motor area, in the vicinity of the interparietal fissure, in the posterior central convolution and the anterior parietal convolution (see Fig. 56).

The tracts for the conduction of descending motor impulses arise in Hitzig's motor areas in the cortex of the anterior and posterior central convolutions, the paracentral convolution, and upper parietal convolution (see Fig. 56, 4, 5, 9, and Fig. 57), pass through the internal capsule, the crusta, and the anterior half of the pons, and unite to form the pyramids. In the pyramids the mass of fibres becomes crossed. The crossed fibres descend through the lateral columns, enter the gray matter, and become connected with the multipolar ganglion cells of the anterior columns. Through the axis-cylinder process of these cells they reach the anterior roots, and from here pass on to the periphery. The smaller portion of the motor fibres pass uncrossed down the inner or median portion of the anterior columns.

The reflex tracts pass from the periphery to the posterior roots of the spinal cord, and the conduction to the anterior roots is probably brought about by the ganglia of the gray matter. Inhibitory fibres, which are probably crossed, descend within the anterior columns.

§ 13. **Concussion of the Brain (Commotio Cerebri).**—By cerebral concussion is meant a shaking up or contusion of the brain *in toto*, with or without recognisable anatomical lesions.

Our knowledge of cerebral concussion has been advanced of late, especially by the experimental investigations of W. Koch and Filehne. In order to bring about concussion of the brain, these investigators struck a dog in the parietal region with repeated blows of a hammer, at the rate of two a second. In one half to three quarters of an hour the animal which had been treated in this way presented the clinical picture of concussion of the brain such as is seen in man—viz., complete unconsciousness, shallow respiration, slowing of the pulse, lowering of the body temperature, relaxation of all the muscles, and insensibility of the skin to strong electrical stimuli.

The post-mortem examination of these animals showed hyperæmia of the pia mater and arachnoid, of the brain and spinal cord, of the brain substance itself, and of the upper part of the medulla. No laceration, rupture of vessels—in short, no mechanical lesions of any kind—and no abnormal consistency of the brain, could be made out. The same is true of man in all cases of true concussion of the brain. The cases are sometimes mild and sometimes fatal. The disturbance caused by the concussion affects the entire brain in the same way; all the centres are at first stimulated and then paralyzed. Fischer holds the view that in concussion of the brain, just as in shock (see Principles of Surgery, § 63), and in Goltz's experiment, a reflex paralysis of the vaso-motor centre in the medulla oblongata takes place. Goltz's experiment consists in repeatedly striking the abdomen of a frog, thus bringing about a peculiar state of collapse, which may prove fatal from paralysis of the heart during the diastole. By the mechanical irritation of the intestines, or rather of the sensory nerves due to the blow, the activity of the central nervous system, and especially of the vaso-motor centre in the medulla, becomes diminished or completely paralyzed. Hence the tonic contraction of the walls of the vessels is diminished or disappears completely, the circulation becomes slower, the blood pressure lower, and finally the circulatory disturbances may attain such a degree that the heart action stops altogether. This reflex paralysis of the vaso-motor centre in the medulla undoubtedly takes place in concussion of the brain, but it does not explain the peculiar nature of the same in which, on the contrary, all the centres are affected.

As Koch, Filehne, and afterward Wittkowski showed, death may take place from concussion of the brain, and still no gross or microscopic lesion be found at the autopsy. In other cases in which concussion of the brain has caused a fatal result, extensive or localized lacerations of the brain substance, capillary hæmorrhages, especially in the region of the fourth ventricle and the medulla, and hæmorrhages into the membranes of the brain, have been found. The clinical symptoms in these last cases are either the same as in simple concussion of the brain without recognisable injury to the brain and its membranes, or they are combined with so-called focal symptoms corresponding to the injury of definite portions of the brain.

Albert also brought about concussion of the brain in dogs by striking the skull with a hammer, and studied the conditions of the circulation in the

brain and the general blood pressure. He tied off those branches of the external jugular vein which did not convey blood from the brain and into the external jugular itself, which is said to carry off the mass of blood from the brain, inserted a cannula, and registered the amount of blood which flowed from the skull during the time that the animal was being struck. A cannula that was inserted at the same time into the femoral artery registered the arterial pressure. In consequence of the blows with the hammer, it was found that with a rise of blood pressure and stimulation of the pneumogastric there was an acceleration of the stream of blood flowing from the skull.

Kocher defines concussion as a contusion of minute portions of brain matter over a considerable area, brought about by the transmission of a shock within the brain aided by the cerebro-spinal fluid. The symptoms of concussion are due to the violence inflicted both upon the nervous centres and the cerebral vessels (Polis).

Symptoms of Concussion of the Brain.—Clinically the same symptoms occur which we have learned to know from the experimental investigations; they are, in short, the same as in a deep sleep. The symptoms on the part of the cortex are the most prominent, and next in order the centres in the fourth ventricle become affected (disturbances of respiration and slowing of the pulse).

The general cerebral symptoms of concussion of the brain consist of mental disturbances (stupor, loss of memory, diminished intelligence, sopor, coma, delirium), headache, vertigo, nausea, vomiting, convulsions, changes in the body temperature (usually a diminution, less often an increase in the same), changes in the pulse and respiration, and often of bladder disturbances (retention of urine).

Besides these general cerebral manifestations, focal symptoms from the injury of certain parts of the brain or pressure symptoms due to intracranial hæmorrhage are present if the concussion is combined with injury to the brain or compression. The most prominent symptoms of simple concussion of the brain are the disturbances of consciousness, which may go on to profound coma.

Vomiting often occurs soon after the injury. Respiration is superficial, but may be, on the contrary, deep and stertorous; the pulse is usually weak, sometimes imperceptible and slow, while sensation in the skin and the electrical excitability of the muscles are diminished.

It is of special interest also, from a medico-legal point of view, that the patient has lost more or less completely and forever all recollection of the time when the injury took place, and of things that occurred just beforehand. This period of time is wiped out, as it were, as far as the memory of the patient is concerned.

According to the degree of the concussion of the brain, this clinical picture may be of course much modified.

In mild cases—after a blow on the head, for example—the patient falls to the ground and presents for a short time the above-described group of symptoms. He then, however, begins to breathe more deeply, opens his eyes, stands up, staggers, it may be, in walking, but is soon completely restored to his senses. Occasionally, however, various disturbances persist for some time, even in these mild cases, such as ataxia—i. e., the inability to perform co-ordinated movements—disturbances of speech, weakness of memory, disturbances in the movements of the eyeball, etc. The disturbances of speech consist either in stuttering, or the patient is unable to pronounce properly certain words or letters (see Aphasia, page 125). The ataxia following concussion of the brain is most evident when the patient tries to take hold of an object, or retain it in his grasp.

In the severer cases there is a condition of marked depression of all the vital functions. There is the same unconsciousness and the same imperfect reaction to outer stimuli, and the conjunctiva is completely insensitive. The pupils are sometimes contracted and sometimes slightly dilated, but they react to very strong light. Respiration and pulse behave in the way mentioned above. Urine and fæces are passed involuntarily, or there is retention of both. If water is poured down the throat, the patient will often swallow. This clinical picture may last for hours or days, and the longer the coma continues, so much the more probable are serious injuries to the brain and its membranes, and so much the worse is the prognosis. If an improvement takes place, the depression is usually followed by a stage of excitement lasting for a very variable length of time. The patient complains of headache, the face is red, and the pulse is of high tension and rapid. The more promptly the patient awakes from his coma the more probable is the diagnosis of simple concussion of the brain, and the more likely is complete recovery to follow, which, it is true, may take place very gradually even in the apparently mild cases.

Fever has been observed in simple concussion, especially in case of injury or irritation of the median portion of the corpus striatum and the mesencephalon, such as the posterior corpora quadrigemina and the sensory nucleus of the fifth nerve (Kocher). Stimulation of these areas produces, according to the experimental researches of Aronsohn, Sachs, and others, an increase in the body temperature.

The prognosis of concussion should therefore be given very cautiously, even in those cases that are apparently mild, since in the latter, also, sudden symptoms of compression due to intracranial hæmorrhage may arise which can prove fatal very quickly if the skull is not opened at once.

All the cases which run an unfavourable course are characterized by an

increase in the coma, more and more marked slowing of the pulse, and finally convulsions and paralyses. In such cases the brain is considerably injured, especially if focal symptoms make their appearance; or there may be, as mentioned above, an intracranial hæmorrhage. Occasionally, even in severe cases, the patients recover, and then succumb later on to a suppurative meningitis or encephalitis. In such cases a fracture of the base of the skull is usually found at the autopsy, and the pus cocci have entered the cranial cavity from the pharynx, the frontal sinuses, the sphenoidal sinuses, or the ear.

In a large number of cases of concussion of the brain which have apparently recovered, a group of symptoms appears later similar to those in concussion of the spinal cord (railway spine), and in fact the manifestations of the latter are, to a great extent, the result of the concussion of the brain which occurred at the same time (Putnam, Walton). For a more detailed description of this I refer to the paragraphs on concussion of the spinal cord (§ 143).

The treatment of concussion of the brain begins with a careful examination of the skull, the hair having been cut short or shaved off, in order to detect more easily any wounds of the soft parts or fractures that may be present. The chief indication is then to overcome the depression of the heart, the respiration, and the body temperature. The patient should consequently be placed in a warm bed, the head kept lowered, warm cloths placed upon the abdomen, and the body wrapped in woollen coverings. As counterirritants, sinapisms applied to the region of the heart, the epigastrium, and the calves of the legs are useful. Ether may be given hypodermically as a stimulant, or in case the pulse is dangerously weak and irregular, atropine (0·0003) in the same way. If the patient can swallow, musk may be administered internally.

The complications—such as, for example, symptoms of compression or fracture of the skull, with or without external injuries, etc.—are treated according to general principles (see §§ 7–9 and § 14).

§ 14. **Compression of the Brain.**—By compression of the brain is understood a disturbance of the functions of the brain due to increased intracranial pressure. Our knowledge of compression of the brain has been advanced of late especially by Bergmann. Among other authors, Flourens, Leyden, Althann, Naunyn, Schreiber, and others have won lasting credit for their work in the explanation of this condition. Leyden was probably the first to study experimentally the subject of diminution of space within the cranial cavity and its effects upon the brain.

Symptoms of sudden compression of the brain may occur primarily in conjunction with injuries to the head from hæmorrhage within the cranial cavity, due to injury of the endocranial blood-vessels, from depressed fractures,

and from foreign bodies that have penetrated into the brain. It may follow traumatisms secondarily from an accumulation of inflammatory products, especially pus within the cranial cavity. It is only the sudden increase of pressure that causes the characteristic symptoms of compression, and not the chronic very gradually developing diminution of space due, for example, to intracranial tumours, increase in the amount of cerebro-spinal fluid, enlargement of the brain, or diminution in the size or change in the form of the skull. In all cases of lack of space within the skull that develops in a chronic way, a gradual compensation takes place by absorption, for example, of the cerebro-spinal fluid or gradual atrophy of the brain. In the case, for example, of circumscribed, slowly developing bone tumours on the inner table of the skull, no symptoms of compression are present. We shall take up here only the acute form of compression resulting from the above-mentioned injuries to the head.

A certain amount of diminution of space within the cranial cavity can be compensated for by the passage of some of the cerebro-spinal fluid from the skull into the vertebral canal as a result of the increased intracranial pressure; the latter, owing to the ligamentous connections between the different vertebræ, is capable of some expansion, the former, on the contrary, is not (see also page 86). If, however, the intracranial pressure oversteps a certain limit, the tension of the cerebro-spinal fluid becomes so great that the circulation in the brain and its membranes is impeded; finally, compression of the capillaries, with corresponding slowing or arrest of the circulation, results, and with this the clinical picture of compression of the brain. The tension of the cerebro-spinal fluid depends upon the force that tends to displace it, and the resistance in the elastic dural sac and in the spinal canal. As Naunyn particularly has shown, the cerebro-spinal fluid is in constant motion. The resorption of the fluid depends in the main on the amount of intracranial pressure. Its resorption also increases with the blood pressure, reaching in the dog, for example, four cubic centimetres a minute. Under normal conditions, according to Naunyn, about one cubic centimetre of cerebro-spinal fluid is secreted in one minute in the dog. The secretion of cerebro-spinal fluid is not dependent upon changes in the arterial pressure, but it can be increased twenty to fifty per cent a minute by thinning the blood with water (Naunyn). The tension of the cerebro-spinal fluid may, according to Grashey, increase to such a degree that it becomes greater than the blood pressure, owing to the fact that the blood is more movable. This view is contrary to the one held by Adamkiewicz. The amount of tension in the cerebro-spinal fluid, or the degree of pressure necessary to cause symptoms of compression, is subject to individual variations. In persons with a weak action of the heart, with disturbances in the circulation due to heart or lung disease, with congestion and hyperæmia of the brain, etc., the symptoms of compression naturally make their appearance earlier than in healthy persons. Bergmann and Duret showed on animals that the symptoms of compression can be immediately relieved upon opening the dural sac or the vertebral canal by dividing the posterior occipito-atloid ligament. The cerebro-spinal fluid then spurts out in a stream, and the retarded respiration becomes normal again.

Falkenhain and Naunyn have recently attempted to estimate the normal

pressure in the subarachnoid space (Archiv für experimentelle Pathologie und Pharmakologie, Bd. xxii, p. 261). It appears to be very variable. In pregnant bitches it is estimated at 100 to 150 millimetres of water (7·5 to 12 millimetres of mercury), in a child one month to a year old at 50 to 200 millimetres of water (4 to 16 millimetres of mercury), and in strong adults still more. An increase in the pressure within the subarachnoid space may result from an increase in the amount of cerebro-spinal fluid, diminution of space in the cranial cavity and vertebral canal, engorgement of the blood-vessels, etc. The amount of disposable space within the cranial cavity and vertebral canal is about fifty cubic centimetres. The real importance of the cerebro-spinal fluid in the etiology of cerebral compression has been differently estimated by the different authorities. Bergmann regards cerebral compression and increased tension of the cerebro-spinal fluid as identical, while Adamkiewicz asserts that it has nothing to do with this phenomenon. Kocher, Deucher, and the author hold a view that is intermediate to that of Bergmann and Adamkiewicz—viz., that the abnormal tension of the fluid does come into consideration in the causation of compression, but that the brain matter can of itself transmit the pressure.

The compression of the brain is at the outset purely local; the veins are first compressed according to Albert and Schnitzler, while according to Bergmann it is the capillaries. The effect is the same in either case, as in Albert's capillary congestion the brain's supply of oxygen is just as inadequate as in capillary anæmia. In consequence of this impaired circulation of blood and inadequate supply of oxygen, irritation of the vaso-motor and pneumogastric centres results, causing the increased arterial tension and pressure, the increased contraction of the small arteries, and the slowing of the pulse. Kussmaul and Tenner showed that the cerebral anæmia following ligation of the arteries that supply the brain acts as an irritant to the vaso-motor and pneumogastric centres, causing the blood pressure to rise as in death from asphyxia.

In the internal jugular vein, on the contrary, the blood pressure falls after a short transitory rise (Albert), because, owing to the increased tension of the cerebro-spinal fluid and compression of the capillaries within the cranial cavity, retardation and diminution of the contents of the vessels result, and hence the propelling force for the blood within the internal jugular is wanting. By watching the vessels of the retina in the vicinity of the entrance of the optic nerve, these disturbances in the circulation within the brain can be directly studied, since, as Schwalbe and Michel have shown, the subarachnoid space communicates with the sheath of the optic nerve. One notices, above all, that the veins of the retina are engorged, because the sheath of the optic nerve is dilated in consequence of the cerebro-spinal fluid that has been pressed into it, and as a result of this compression the escape of venous blood is impeded (Manz).

The child's brain is especially sensitive to compression, because the amount of cerebro-spinal fluid is comparatively small while the amount of brain matter is large.

In consequence of the above-described circulatory disturbances within the cranial cavity, or rather brain, corresponding functional disturbances take place. These take the form of anæmia of those portions of brain which

are directly pressed upon, and congestive hyperæmia of the more remote portions; both the anæmia and hyperæmia are harmful to the brain by disturbing, first of all, its nutrition. The different centres in the brain possess a varying power of resistance to these disturbances of circulation, or, in other words, of nutrition, some being more sensitive than others. According to Huguenin, the functional disturbances due to cessation of the circulation affect the different areas of the brain in about the following order: The first to suffer alteration is the cerebral cortex, then the corona radiata, the gray matter of the spinal cord, the pons region, and lastly the medulla. The very sensitive cortex may be already over-irritated or paralyzed, while the functional disturbances of the medulla have scarcely made their appearance—i. e., unconsciousness precedes the irritation of the respiratory, vaso-motor, pneumogastric, and convulsive centres. Death results in compression of the brain from increasing paralysis of the vital centres in the medulla, especially from paralysis of respiration.

Symptoms, Prognosis, and Diagnosis of Compression of the Brain.—The clinical picture of compression of the brain is seldom seen by itself, but it is usually complicated by symptoms of concussion and injury of the brain matter.

In animals, Leyden, Pagenstecher, Duret, and others have determined the symptoms of compression pure and simple by applying pressure to the surface of the brain by means of forced injections into the cranial cavity or the subarachnoid or subdural spaces of hardening wax, thin gelatinous fluids, or warm salt solution. The salt solution that Naunyn and others injected into the subarachnoid space was absorbed in large amounts. According to Falkenhain and Naunyn, the symptoms of compression are partly direct in consequence of the cerebral anæmia from compression of the capillaries, and partly indirect in consequence of congestion of the blood and lymph. The latter takes place from a much slighter rise of pressure than the former. A sudden rise of intracranial pressure can also take place in the case of tumours by a lowering of the blood pressure, for example, since, owing to the resulting diminished resistance of the capillaries to the pressure upon them, cerebral anæmia ensues. Leyden was the first to show that the symptoms of compression appear in a certain order, and that in a certain sense the same elevations of pressure always cause the same symptoms.

The symptoms of compression pure and simple, which have been determined experimentally, may be divided into two periods: (1) the period of irritation, and (2) the period of depression (stupor, coma).

The first symptom of compression is pain caused by pressure on the dura, as the brain matter itself is not sensitive. Loss of consciousness then ensues, varying in degree up to the deepest coma, with absolute loss of sensation and muscular paralysis, since, as we

saw above, the cortex is the part that is most sensitive to changes in the circulation or nutrition. "During this night of the senses," as Bergmann so aptly says, "the automatic apparatus within the spinal cord is alone awake," until it also succumbs to the increasing disturbance of circulation. According to Duret, the functional disturbances remain confined to the cortex if the column of water in Leyden's apparatus corresponds to only ten to twelve centimetres of mercury.

If the amount of compression increases, convulsions take place which resemble epileptic or eclamptic seizures, and are to be regarded as the sign of a severe, rapidly increasing pressure on the brain. Changes in the pulse then follow, at first slowing of the pulse from stimulation of the pneumogastric, and finally quickening from paralysis of the same. The slowing of the pulse sometimes precedes the loss of consciousness. With the altered heart action goes hand in hand the change in the respiration; the latter is at first irregular, then later, during coma, regular, slow, and often stertorous, as in sleep. If the compression increases, the respiration becomes irregular again. Death takes place mainly from paralysis of respiration; it is usually one or two minutes after the last breath before the heart stops beating.

The other symptoms are less constant in animals—such as, for example, vomiting and repeated involuntary defecations. The body temperature is but slightly changed; in the most severe cases it drops continuously until death.

In man the clinical picture of compression is, generally speaking, the same as that seen in animal experimentation. Here, also, there is a stage of irritation, followed by one of depression. The symptoms of irritation in the first stage consist of marked restlessness, over-sensitiveness to sensory stimuli, a heavy feeling in the head, and especially headache. The face is unusually red, the pupils contracted, the pulse slow, and the tension in the carotids increased. With increase in the amount of compression there follow nausea, vomiting, confusion of the intellect, and sleep. The loss of consciousness takes place either gradually or suddenly. The other manifestations are exactly the same as in the experiments on animals, except that convulsions in man in case of compression pure and simple—caused, for example, by a depressed bone or intracranial hæmorrhage—are usually, or in fact always absent, because compression due to a depressed bone is too slight, and that due to intracranial hæmorrhage increases too slowly.

Furthermore, among the symptoms of compression seen at the bedside, localized functional disturbances of the brain (so-called focal symptoms) come into prominence, because that portion of the brain

lying nearest the point to which the pressure is applied is affected first and the most seriously. Hence complete or incomplete unilateral paralyses, especially in the distribution of the motor-oculi nerve, are usually present. According to Leyden, hemiplegia is a sign of injury or disease of the brain matter, and it is absent in compression brought about experimentally. Hence the differential diagnosis between compression and injury of the brain is sometimes difficult.

It is of special interest to note the behaviour of the pupil and the fundus of the eye. The pupil on the same side as the compressed portion of brain is at first contracted, and in the more marked degrees of compression it is dilated to the fullest extent, while the one on the sound side is moderately dilated. In consequence of the disturbed co-ordination of the movements of the eye the bulb has an oblique position; oscillations of the bulb are less frequent. Examination of the fundus of the eye reveals choked disk, because the sheath of the optic nerve is dilated by the cerebro-spinal fluid that is pressed into it, and in this way the end of the optic nerve within the eye is compressed (Schwalbe, Michel, Manz). The presence of choked disk is, as is well known, of great importance for the diagnosis of intracranial tumours, and it also occurs in hydrocephalus and the later stages of tubercular meningitis. In injuries of the head the surgeon should lay more stress upon the ophthalmoscopic examination than has heretofore been the case. Atrophy of the optic nerve is comparatively common in injuries of the head, and is often a result of the choked disk (Bergmann, Galczowski, and others).

For the final outcome of compression of the brain it is especially important to know the cause and nature of the injury, the size of the compressing substance, the duration of the compression, and, above all, whether the same is increasing or diminishing. Patients can completely recover from the stupor combined with a very slow pulse, even though it lasts for weeks. Deep coma, with complete muscular paralysis and loss of sensation for all external stimuli, with irregular deep respiration and dilated pupils, probably always results fatally. Paralysis of the circulatory and respiratory centres means a speedy end. Many patients who have received an injury to the head and developed symptoms of compression die within forty-eight hours. In other cases the symptoms disappear gradually, and complete recovery ensues. Focal symptoms due to simultaneous injury to the brain disappear only very gradually, or remain permanently.

In cases of depression of the cranial bones where there are symptoms of compression of the brain, the latter may disappear, although the depression is not remedied. In such cases the brain gradually

accommodates itself to the diminution in the amount of space in the way described above.

Treatment of Compression.—The treatment of compression of the brain depends, in the first place, upon the nature of the injury. If possible, the cause that produces the compression must be overcome at once. But this is easier said than done. In the case of depressed fractures it is not the depth of the depression that decides the treatment that is necessary, but the injury to the intracranial blood-vessels and the brain, that may be present at the same time. In case of hæmorrhage from the middle meningeal artery, for example, the skull should be trephined and the main trunk of the wounded artery exposed and ligated (see § 15).

Generally speaking, temporary resection of the cranial bones, with the formation of a pedunculated flap, consisting of soft parts and bone, after Wagner, is preferable to trephining (see page 167). Moreover, in acute compression due to tumours the symptoms may be relieved, only temporarily to be sure, by a temporary resection, followed, perhaps, by puncture and drainage of the lateral ventricles. In the latter operation I prefer opening the skull by means of a small trephine three quarters to one centimetre in diameter, in place of an extensive resection of the skull. Finally, puncture of the spinal canal in the lumbar region is useful in some cases. For the operative treatment of the various forms of injury, particularly fractures of the skull, the reader is referred to the paragraphs on these subjects.

The special treatment required in compression consists, above all, in improving the impeded circulation. If the heart's action and arterial tension are not very much reduced, venesection is to be recommended, because in this way the flow of venous blood from the head is stimulated, the amount of blood is diminished, the blood pressure in the brain and the entire arterial system is lowered, and hence the circulation in the latter is facilitated. Leeches on the temples and behind the ear are also useful. The head should be elevated, in order to help the escape of venous blood from the head. By the use of strong cathartics the absorption of cerebro-spinal fluid is aided, and in this way the brain is relieved somewhat from pressure. If the vessels have insufficient tone, Bergmann recommends ergotin, small doses of atropine, and the application of the galvanic current, in order to strengthen the power of resistance of the arterial walls and prevent their dilatation. The cathode is placed on the inner border of the sterno-mastoid muscle or in the auriculo-mastoid fossa, in order to come as near as possible to the sympathetic nerve.

It is the usual custom to apply cold, preferably in the form of an

ice cap or coil, and occasional douches of cold water, if the latter is not contraindicated on account of an antiseptic protective dressing. In no case should the aseptic healing of a head injury be interfered with. The ice cap or coil may be applied over the antiseptic dressing.

For the treatment of any complications that may arise the reader is referred to the proper paragraphs.

The technique of trephining and temporary resection of the skull is described in § 23.

§ 15. **Injuries of the Intracranial Blood-vessels** lead either to external hæmorrhage—in compound fractures, for example—or extravasations of blood inside the cranial cavity. In the latter the extravasation may take place between the dura mater and the bone, or beneath the dura, between the latter and the soft coverings, and in the tissue of the latter, or finally within the brain itself.

External hæmorrhages, or those between the dura and bone, are most commonly the result of injury of a sinus, the middle meningeal artery, and less frequently of the internal carotid.

I. **Injuries to the Sinuses.**—Injuries to the sinuses are either ruptures due to fractures of the skull or to displacement of the cranial bones—for example, during birth—or they are caused by incised, punctured, or gunshot wounds, or penetrating splinters of bone. The superior longitudinal and lateral sinuses are the most likely to be injured on account of their situation (see Fig. 58). Ruptures due to displacement of the bones and fractures appear to involve the lateral sinuses most frequently, because they are more intimately attached to the bone, and the violence is usually directed from above downward and backward. If, after injury to a sinus, the blood can not escape externally, the dura is lifted away from the bone more and more, and corresponding symptoms of compression then result. The latter develop much more slowly and to a less extent than in hæmorrhage from the middle meningeal artery, and may be absent entirely. Hæmorrhage from a sinus is easily arrested spontaneously if the tear is not too large, as the pressure in the same is slight, and it is closely connected to the bone. In case of an external wound the blood coming from a rent in a sinus flows out in a continuous stream. By means of compression and the application of a suitable antiseptic dressing, the hæmorrhage can easily be arrested.

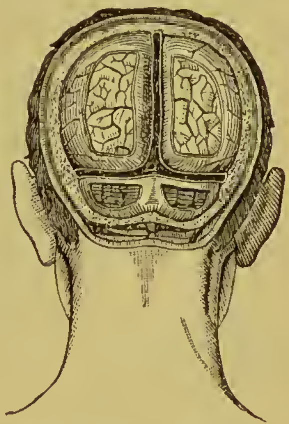


Fig. 58.—Longitudinal and lateral sinuses. The exposed portions of the brain are seen through a hole in the dura, and are covered by the arachnoid and pia mater with its blood vessels.

In numerous cases of injury to a sinus complete recovery has resulted. Death is rarely due to hæmorrhage, but is usually caused by complications (injury to the brain, meningitis, septicæmia, pyæmia).

According to experiments made by Schellmann and clinical experience, a wound in a sinus can heal without obliteration of the sinus in question. If a narrowing or complete obstruction of a large sinus takes place at the point of injury, it does not necessarily follow that disturbances will result. The most dangerous thing that can happen is the formation of a thrombus, which may suppurate on account of the microbic infection through an open wound. In such cases death results from sepsis or pyæmia.

Volkmann and Genzmer have seen death take place from the entrance of air into a sinus that was opened during the removal of a sarcoma of the dura. According to Bergmann and Cramer, it is not possible, under ordinary circumstances, for air to enter a sinus, because the pressure in the veins of the skull is never negative. I believe, however, that the entrance of air into the opened sinus is favoured by deep respirations on the part of the patient and by sponging the wound.

The treatment of open wounds of a sinus consists in arresting the hæmorrhage by means of an antiseptic dressing that exerts pressure. Any spicules of bone which have punctured the sinus in the case of a fractured skull should of course be removed. If symptoms of compression are present with the skull intact, trephining or temporary resection of the cranial bones may be indicated (see § 23).

II. **Injuries of the Middle Meningeal Artery.**—Wounds of the middle meningeal artery often result from incised and punctured wounds of the head, gunshot injuries, and from fractures of the skull in general, and they are the most frequent cause of hæmorrhage between the bone and dura.

The middle meningeal artery (see Fig. 59 and Figs. 62–64), the largest branch of the internal maxillary, enters the cranial cavity through the foramen spinosum and runs in the branching grooves on the inner surface of the skull between the dura and the bone. It sometimes arises from the ophthalmic artery (see Fig. 64). Within the cranial cavity it divides into an anterior and a posterior branch. The anterior branch passes to the frontal region; the posterior crosses the petrous portion of the temporal bone in a horizontal direction and reaches the occipital bone. Both branches subdivide into smaller ones, some of which perforate the bone and supply the soft parts of the skull, as well as the lining of the facial cavities (Figs. 62–64).

In fractures of the skull, the artery is either torn simultaneously with the division of the bone, or it is injured by sharp edges or splin-

ters of bone. Rupture of the middle meningeal artery may also occur without a fracture of the skull, in case, for example, of changes in its form, or depressions of the bone which disappear again immediately. Sometimes the rupture does not occur at the point where the violence was inflicted. This is easily explainable if we call to mind the mechanism of indirect fractures of the skull. A blow or fall on the left temporal region can thus cause a rupture of the right meningeal artery. In rare cases the artery is torn away at the foramen spinosum. The most frequent injuries of the middle meningeal artery occur during its course along the inner surface of the temporal and parietal bones (see Figs. 62–64). The hæmorrhage following injury to the middle meningeal artery is usually very considerable; it varies, according to Bergmann, between sixty and two hundred and forty grammes or more. Very frequently the adjoining portion of the brain is likewise injured, especially in comminuted fractures and circumscribed depressed fractures.

Fig. 59.—Branches of the middle meningeal artery after removal of the temporal muscle and the overlying bone.

The symptoms of injury to the middle meningeal artery with a compound fracture in the temporo-parietal region and external hæmorrhage are very evident, and could only be mistaken for hæmorrhage from the deep temporal arteries. In such cases complete exposure of the source of the hæmorrhage will clear up the diagnosis.

If the blood does not escape externally, as in the case of a simple fracture, for example, the typical picture of compression results, as described in § 14. This is caused by the formation of an extravasation of blood between the dura and the bone which often increases in size very rapidly.

It is characteristic of injury to the middle meningeal artery, and of great importance for the diagnosis, that the patient feels comparatively well directly after the injury, but that in a few hours symptoms of compression make their appearance, which are due to an increase in the amount of hæmorrhage. These symptoms consist of headache, nausea, vomiting, restlessness, lassitude, stupor, then sleep, coma, slowing of the pulse, etc. In other cases this period of incubation is absent, and the patients become unconscious immediately after the injury, in consequence of the simultaneous concussion or injury of the brain. If hemiplegia occurs immediately after the injury, it is due to injury of the brain in the motor region; but if it does not

develop until later on, it is caused by compression of this region (see Fig. 56).

The prognosis is not good. According to Bergmann, out of ninety-nine cases only sixteen recovered. In twelve of the cases that recovered the hæmorrhage took place externally, three were cured by trephining, and one without trephining after a long illness. The other cases were all fatal. Thirty-six died within twenty-four hours, seven within forty-eight hours, four on the third day, and ten later on. In three cases the ruptured artery was on the side opposite the fracture. The most frequent cause of death is progressive œdema of the brain in consequence of the increasing compression, with paralysis of the medulla, and, in case of a compound fracture, suppurative meningitis.

The diagnosis of injury of the middle meningeal artery is easy in the case of an open wound with external hæmorrhage. In all cases where there is a subcutaneous injury the nature of the accident, the location of a fracture in the temporal and parietal region, and, furthermore, ecchymoses, are of importance. The fact is of special importance that the patient felt comparatively well after the injury, and then, some hours later, showed symptoms of compression (headache, vomiting, unconsciousness), in consequence of the increasing hæmorrhage. After a compound fracture a beginning acute suppurative meningitis may resemble compression.

The treatment of injury to the middle meningeal artery consists of prompt operative measures. If the hæmorrhage is external, as in a compound fracture, for example, the injured artery should be exposed as completely as

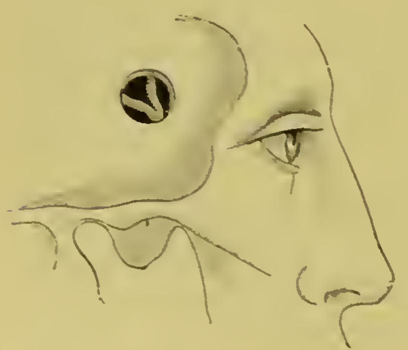


FIG. 60.—Trephine opening for ligation of the middle meningeal artery (Hueter and Vogt).

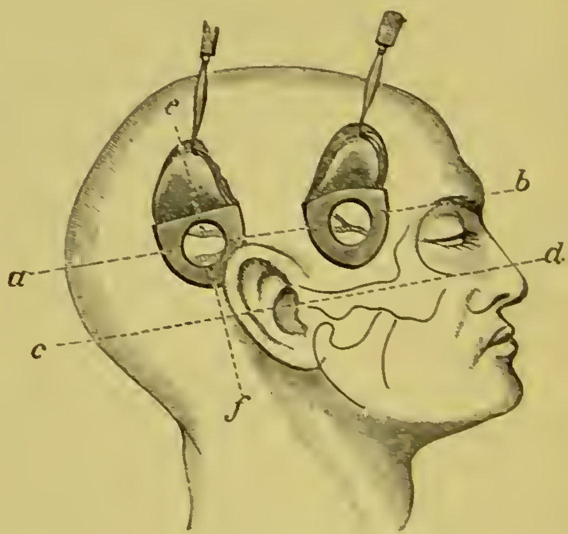


FIG. 61.—Trephine openings for finding both branches of the middle meningeal artery (Krönlein).

possible. If necessary, the wound should be enlarged, the bone at the point of fracture sufficiently removed with a chisel or rongeur forceps, splinters of bone picked out, the blood clots scraped away with the sharp spoon, and the vessel, if possible, seized with an artery clamp

and ligated or a suture passed around it. In cases in which it was found difficult to arrest the hæmorrhage by ligation the common carotid has been tied with success. Among seven cases of ligation of the common carotid for this injury in the American civil war, three were, according to Bergmann, successful.

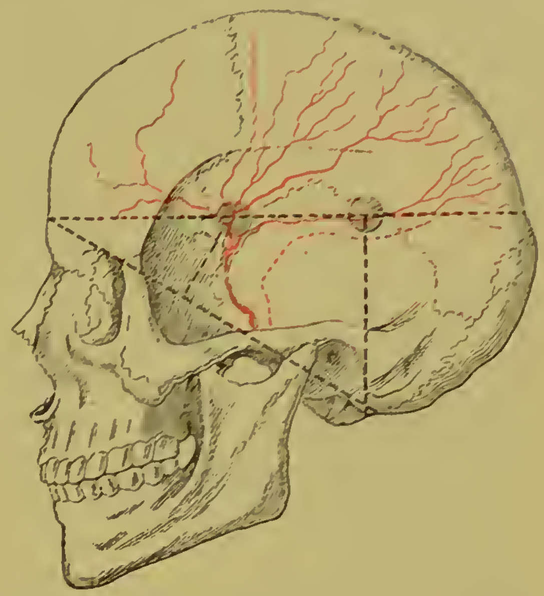


Fig. 62.—Ramification of the middle meningeal artery (Steiner).

In subcutaneous injuries of the artery, with or without simple fracture of the skull, the cranial cavity should likewise be promptly opened by means of the trephine or, better still, the chisel and mallet. Instead of the typical operation of trephining, temporary resection of the skull may be employed in suitable cases (see § 23). One should not delay too long, as the majority of those injured, as mentioned above, die within the first twenty-four hours. Trephining and temporary resection of the cranial bones are entirely without danger if performed under aseptic precautions.

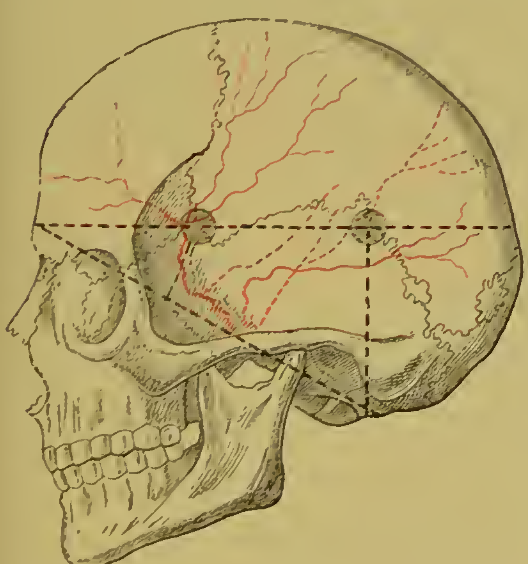


Fig. 63.—Ramification of the middle meningeal artery (Steiner).

For finding the artery, Hueter and Vogt have advised opening the skull with a trephine or chisel at the point indicated in Fig. 60—i. e., the angle formed by the junction of two lines, one of which runs in a horizontal direction two fingers' breadth above the zygoma, while the other ascends vertically a thumb's breadth behind the frontal process of the malar bone. The blood clots must then be removed as completely as possible with a sharp spoon, and the artery tied or a suture passed around it.

Krönlein's method of procedure is very much to be recommended. He distinguishes, according to the point of rupture of the artery, three hæmatomata—an anterior, middle, and posterior. He advises trephining first at the usual place, three to four centimetres behind the frontal process of the malar bone, and in case one

does not find the hæmatoma, a second opening is made farther backward in a horizontal direction in the neighbourhood of the parietal eminence and somewhat above and behind the ear (see Fig. 61). Both trephine openings should lie in the line *a b*, drawn directly backward from the supraorbital border which runs parallel with the horizontal line of the head *c d* (external auditory meatus—infraorbital border line, Virchow's German horizontal). In this line the anterior trephine opening should, as has been said, be made three to four centimetres behind the malar process of the frontal bone, and the posterior opening at the point of intersection of the horizontal line *a b* and a line *e f* drawn upward, posterior to the mastoid process and three to four centimetres behind the external auditory meatus.

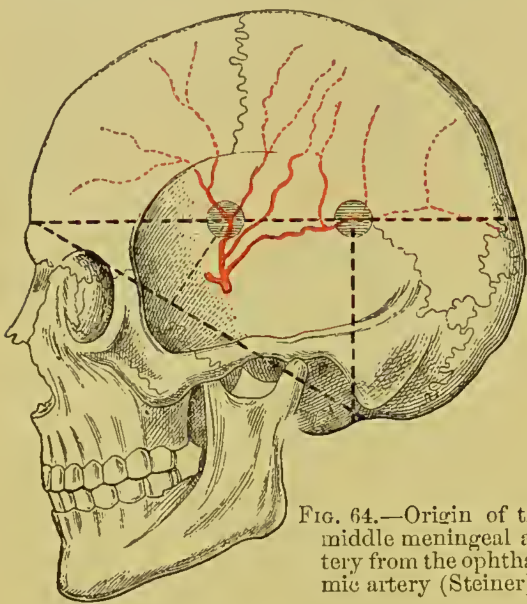


Fig. 64.—Origin of the middle meningeal artery from the ophthalmic artery (Steiner).

Steiner, on the basis of his painstaking investigations, gives the following rules for finding the middle meningeal artery (see Figs. 62–64): To find the anterior branch of the artery, a line is drawn from the centre of the glabella to the apex of the mastoid process, and at the centre of this line a perpendicular is erected. The point of intersection of this perpendicular with a horizontal line drawn about the skull, through the centre of the glabella, gives us the anterior lower parietal angle, or the anterior trephine opening. The second trephine opening, at which the posterior branch is found in ninety per cent of all cases, is best made at the point of intersection of the above-mentioned horizontal line with a vertical line erected just in front of the mastoid process. In all cases, when possible, the skull should be opened by the formation of a flap of soft parts and bone, with its base below, near the zygoma (page 112).

Bergmann is right in calling attention to the fact that, after opening the skull, one may be deceived in regard to the source of the hæmorrhage, as the latter may be beneath the dura. In such cases the subdural extravasation of blood is spread out over the hemispheres of the brain like a cap, and trephining is of no avail, because the blood can not be sufficiently removed. If the subdural extravasation is still circumscribed, opening the skull may be successful if upon cutting through the dura the hæmorrhage can really be arrested.

III. **Injury to the Internal Carotid Artery.**—Injury of the internal carotid artery is much rarer than that of the middle meningeal, and its prognosis is much worse, being, in fact, almost always fatal. Injury of the artery has been caused by penetrating wounds, especially through

the orbit, by gunshot wounds, and in some cases by loose splinters of bone in fractures of the skull. In fissures through the carotid canal, in close proximity to the carotid artery, the artery often remains uninjured, because the cavernous sinus that surrounds it allows it a certain amount of change of volume and displacement. But it is easily torn in the case of wide fissures in its vicinity. Occasionally an arterio-venous aneurism results from its injury, which, as is well known, is a not infrequent cause of pulsating exophthalmos (§ 28). According to Rivington, out of seventy-three cases of pulsating exophthalmos forty-one were traumatic. For the diagnosis of an aneurism of the internal carotid, paralysis of the abducens nerve, which runs along the carotid canal close to the artery, is important (Shalkhauer). Paralysis of the motor oculi has also been observed (Wecker and Nunneley).

The treatment of aneurisms of the internal carotid consists in ligation of the artery, the results of which have been very favourable (Rivington, Nieden). According to Nieden, of forty-nine cases thirty-three were cured by ligation, six improved, in three cases the operation was without effect, and in seven cases death occurred. Before the artery is ligated digital compression should be used for some time, so that the brain may become accustomed to the diminished supply of blood. (For injury to the internal carotid see also under Diseases of the Ear.)

IV. **Hæmorrhage between the Dura Mater and Soft Membranes, and within the Latter.**—Hæmorrhages beneath the dura are frequent in injuries of the head, especially fractures of the skull, with laceration of the cortex, and also in concussion of the brain without fracture. The blood comes mainly from the small veins and capillaries, or from an injured sinus. The amount of blood that collects is often very great, so that one or both hemispheres may be covered by an extravasation as far as its base. The blood is absorbed only very slowly, and sometimes forms the starting point of a pachymeningitis (Huguenin, Schneider, Birch-Hirschfeld).

The symptoms of a subdural hæmorrhage consist in the signs of compression, which, however, develop much more slowly and are less marked than in hæmorrhage from the middle meningeal artery.

The coma may last for weeks and still complete recovery take place. Circumscribed intrameningeal hæmorrhages cause no symptoms in the same way that extensive lacerations of the cortex may be without symptoms and cicatrize without functional disturbance, if another portion of the brain can assume the function of the portion affected. The circumscribed or disseminated capillary hæmorrhages in the cortex in concussion of the brain, for example, only cause focal symptoms when they occur in certain places, such as the motor area or in the medulla.

Injuries of the large arteries of the brain, such as the middle cerebral, cause death very quickly, with marked symptoms of compression.

The treatment of subdural hæmorrhages corresponds in the main to the principles laid down on page 102 for the treatment of concussion of the brain.

For the treatment of the symptoms of compression the reader is referred to § 14. Here, also, all congestion of the head is to be avoided as far as possible, as otherwise the pressure on the brain may reach a dangerous degree.

For the treatment of injuries of the skull see §§ 2, 3, and §§ 7–9.

Upon increase of the symptoms of compression, trephining has repeatedly been resorted to, probably because injury to the middle meningeal artery was suspected. After opening the skull it would be necessary, in case of subdural hæmorrhage, to slit open the dura in order to remove the blood clots. Only circumscribed subdural extravasations can be removed after incision of the dura, and these would probably disappear entirely by gradual resorption. Bergmann is hence justified in condemning incision of the dura in subdural hæmorrhage, on the ground of its being useless and harmful.

Intrameningeal hæmorrhages are also observed in asphyxiated or still-born children, in consequence of fractures of the skull or displacement of the cranial bones, with rupture of the subarachnoid vessels, especially the veins. In this way very extensive subdural hæmorrhages may occur, which prove fatal from paralysis of the respiratory centre as soon as the circulation in the placenta ceases after birth—i. e., the child becomes asphyxiated. Occasionally the asphyxia of the child in such cases is apparently over, and it even cries, but, nevertheless, death soon takes place suddenly. The certain diagnosis of these subdural hæmorrhages in infants is hardly possible, and no form of treatment is of avail.

§ 16. **Injuries of the Nerves within the Cranial Cavity.**—In connection with injuries of the intracranial blood-vessels we shall take up briefly injuries of the nerve trunks during their course within the cranial cavity and their passage through the skull, in so far as they are of surgical importance. For a more detailed description, especially of the symptomatology, the reader is referred to Bergmann's work on injuries of the head and the books on neurology.

In injury of the nerve trunks the paralysis is, of course, always on the injured side, while in injuries of the nerves, at their point of origin in the brain, the paralysis is on the opposite side.

Injuries of the olfactory nerve occur most commonly in gunshot wounds through the root of the nose, and in fractures of the base of the skull through the cribriform plate. The olfactory nerve can also be lacerated without fracture of the skull by violence applied to the forehead or root of the nose, or

by *contre-coup* from a blow or fall on the back of the head. In these cases the frontal lobe is usually contused at the same time. The paralysis of the olfactory nerve may be either transitory or permanent. The prognosis as regards restoration of the sense of smell is, of course, most unfavourable in case of rupture of the nerve, while in case of contusion of the nerve and hæmorrhage into its sheath the paralysis is only temporary. Occasionally the paralysis of the sense of smell is combined with other disturbances, such as disturbances of speech in the form of motor aphasia due to injury of the brain in the neighbourhood of the third frontal convolution, or with visual disturbances due to injury of the optic nerve.

The sense of taste, which requires the co-operation of the sense of smell, is blunted in case of paralysis of the olfactory nerve. In paralysis of the facial nerve the sense of smell is only apparently disturbed, owing to the fact that the dilating muscles of the alæ nasi are paralyzed, and hence the inhalation of odorous material into the nose is interfered with.

Injuries of the optic nerve are most frequent in fractures of the base in the neighbourhood of the orbits from punctures or gunshot wounds. Bergmann mentions a case in which a shot healed up in the optic nerve, and gave rise secondarily to atrophy of the eyeball (Butter). In case of complete division of the optic nerve, blindness in that eye results at once, and the same is incurable, since, as in animals, regeneration of the divided optic nerve has never been observed. If there is a slight hæmorrhage within the sheath of the optic nerve, the disturbance of function is usually only temporary, but in case of large extravasations atrophy of the nerve may take place. Hæmorrhage within the optic sheath is often a result of fracture of the base, and if the latter passes through the optic foramen the nerve becomes more or less lacerated. In other cases the optic nerve is injured by broken-off splinters of bone from the roof of the orbit, for example, or the optic foramen. In gunshot injuries in which the ball passes transversely through both orbits, blindness of both eyes may occur, but there are cases on record in which both optic nerves remained uninjured.

Contusion or laceration of the motor-oculi nerve occurs most commonly in fractures of the orbit. Temporary paralysis of this nerve has also resulted from pressure of the forceps during delivery. We have already mentioned that in two cases paralysis of the motor-oculi nerve was caused by an arterio-venous aneurism of the internal carotid artery, following injury of the same within the cavernous sinus. Occasionally hemiplegia is present at the same time, in which case there may be an injury to the centre for the motor-oculi nerve in the cortex of the brain, which is adjacent to the centre for the extremities.

Paralysis of the fourth nerve has been observed by Bergmann and others to follow injuries of the head. In Bergmann's case double vision (diplopia) on looking downward was present six years and a half after the injury.

Paralysis of the abducens nerve is not frequent in fractures of the base, and it is occasionally observed in pulsating exophthalmos, or, in other words, an arterio-venous aneurism of the internal carotid artery. Rupture of the abducens nerve in the furrow of the petrous portion of the temporal bone, which is so often fractured, has only been demonstrated once on the cadaver. It is remarkable that this nerve, in spite of its long course along the base of

the skull, is, comparatively speaking, so rarely injured. This is also shown in Putscher's careful statistics of cases. Among ninety-seven cases of fracture of the skull which were treated in the years 1885 to 1889, in the Charité Hospital in Berlin, paralysis of the abducens nerve was present only twice (Bardeleben). Paralysis of this nerve is probably caused not only by direct injury of the nerve, but also by traction on the same before its entrance into the cavernous sinus and by compression from an extravasation of blood. According to Putscher and Schroeder, literature contains fifty-eight cases of paralysis of the abducens nerve due to injuries, such as fracture of the skull; they are partly unilateral and partly bilateral isolated paralyses, or they are complicated by other paralyses and brain lesions. Paralyses of the abducens are partly basal alone and partly cerebral. The facial and auditory nerves are sometimes paralyzed at the same time, owing to their lying close together on the petrous portion of the temporal bone. In case of simultaneous paralysis of the abducens and facial nerves an injury to the fourth ventricle is possible, as the nuclei of the facial nerve lie here in close proximity to the origin of the abducens.

Division of the fifth nerve alone at the base of the skull has, according to Bergmann, never been demonstrated on the cadaver, but he mentions two cases in which it was as good as proved. On the other hand, anæsthesia of the fifth nerve, combined with other nerve lesions and severe cerebral symptoms, has been repeatedly observed in fractures of the base. The disturbances of sensation in the distribution of the fifth nerve following injuries of the head always result in neuroparalytic inflammations of the eye. This ophthalmia is partly due to injury of the trophic nerve fibres in the fifth nerve, and partly to loss of sensation in the eye, on account of which the eye can not protect itself sufficiently from external injurious influences.

The facial nerve is most commonly injured by pressure of the forceps during delivery, by a blow or gunshot injury at its point of exit from the skull, and finally during its course through the petrous portion of the temporal bone in fractures of the base, with or without injury to the auditory nerve. In fractures of the base the injury is almost always unilateral, although symmetrical fractures of both petrosal bones is comparatively frequent. Bergmann mentions two cases only of bilateral paralysis. It is possible, however, that paralysis of both facial nerves may be easily overlooked. In the majority of cases of facial paralysis due to fracture of the base the functional disturbance resulting from rupture of the nerve is permanent; recovery is most likely to take place when the nerve is only contused. Occasionally the paralysis of the facial nerve does not appear until the second to the fourth day, or still later, after the injury. It is then probably always caused by an ascending neuritis, and is often the forerunner of a suppurative basal meningitis. For the location of the injury or the course of the fracture it is important to note whether the soft palate is paralyzed or not. When there is no paralysis of the soft palate the facial nerve is injured below the geniculate ganglion—i. e., below the point where the large petrosal nerve comes off. If, however, paralysis of the velum is present, the injury is above the ganglion. The location of the injury to the facial nerve can also be determined by testing the sense of taste. The chorda tympani, which leaves the facial nerve inside the Fallopian canal and crosses the

tympanic cavity, transmits, as is well known, the sensation of taste, and it receives its gustatory fibres from the spheno-palatine ganglion by means of the Vidian nerve. If, therefore, the sense of taste is disturbed, the facial nerve is injured below the ganglion, where it contains the taste fibres, but otherwise above the ganglion. If the auditory nerve is also paralyzed, there is probably a longitudinal fracture of the petrous portion of the temporal bone with a tearing away of the facial and auditory nerves at their point of entrance into the bone, while in transverse fractures in the vicinity of the posterior wall of the tympanic cavity the auditory nerve is usually left intact. (For injury of the petrosal nerves see page 61.)

For paralysis of the facial nerve in diseases of the ear the reader is referred to the latter.

Paralysis of the auditory nerve also occurs in fractures of the petrous portion of the temporal bone, and in hæmorrhages within the labyrinth and the tympanic cavity without fracture. Rupture of the auditory nerve from fractures of the base, passing through the petrous portion of the temporal bone, is not so frequent as that of the facial nerve, because the latter runs a longer course through the bone. If there is deafness in both ears it is usually permanent, and caused by fractures of the base on both sides with rupture of the nerve. If there is deafness in only one ear, and at the same time immediate paralysis of the facial nerve, including the palatine branches, but without alteration in the sense of taste, both nerves are probably injured in the vicinity of the internal auditory meatus. The deafness is sometimes the result of injury to the labyrinth, which may take place through the external auditory canal.

It may be mentioned in this connection that, according to Goltz and Flourens, the auditory nerve is not only the nerve of hearing, but also the preserver of equilibrium. This is denied by Böttcher, Brunner, and Bergmann.

Bergmann mentions one case of isolated injury of the glosso-pharyngeal nerve in which disturbances of speech and deglutition and ulceration of the tongue occurred, and the patient died suddenly of œdema of the glottis. The autopsy showed the presence of a hæmorrhage in the roots of the nerve.

But little is known of injuries to the pneumogastric, spinal accessory, and hypoglossal nerves within the cranial cavity. Diberder mentions a case of rupture of the hypoglossus from a fracture through the anterior condyloid foramen. We shall return to a consideration of injuries and diseases of these nerves in connection with injuries of the brain and the surgery of the neck. It need only be mentioned here that paralytic dysphagia may originate in the cerebral centres of the glosso-pharyngeus, pneumogastric, and spinal accessory nerves.

§ 17. **Injuries of the Brain and Medulla: Contusions of the Brain.**—Among injuries to the brain we shall take up first contusions. Contusions of the brain are caused by various kinds of violence, and most commonly occur in connection with concussion of the brain and changes in the form of the skull with or without fracture of the latter. Injuries to the brain are either open—i. e., contused wounds of the

brain with injury to the soft parts and the bone—or they are subcutaneous, or rather subosseal. The subcutaneous contusions include those that take place in concussion and simple fractures, and the open contusions those in compound fractures.

The degree and extent of contusions of the brain are very variable. They may take the form of punctate hæmorrhages or contused areas the size of a hazelnut or walnut, or the injury is more diffuse, involving a large part of the brain. Innumerable capillary hæmorrhages scattered through the whole brain are most commonly found in concussions. The appearance of the injured portion of the brain is in mild cases that of a hæmorrhagic focus such as is seen in circumscribed inflammation or embolic processes—i. e., one sees on section a reddish-yellow spot with numerous red points due to capillary hæmorrhages. In the more severe injuries large blood clots are found embedded in the lacerated brain matter, and in the worst cases of gunshot wounds and mangling of the brain from run-over accidents the portion of the brain in question is transformed into a brownish pulp consisting of blood and brain matter, which not infrequently contains various foreign bodies, such as small pieces of bone, hairs, sand, bullets, etc. The periphery of the injured portion of brain is usually surrounded by a zone of red softening. Occasionally true rupture of the cortex occurs, which not infrequently extends into the white matter and ventricles of the brain. This may take place in run-over accidents or in concussion of the brain with intact skull.

The injured portion of brain is usually situated at the point where the violence was applied to the skull, but it may be on the opposite side; a fall on the occipital region may cause, for example, a contusion of the frontal lobe, and a fall on the parietal region a contusion of the base, with or without injury to the brain at the place where the violence is inflicted. When one, moreover, considers that the brain is comparable to a sponge filled with water, it is easy to understand that by compression of the skull and the brain the fluid within the brain—i. e., the blood, lymph, cerebro-spinal fluid, and the contents of the ventricles and central canal of the spinal cord—causes laceration of the soft brain matter in whatever direction it is pressed. In this way may be explained the injuries of the brain matter lining the walls of the ventricles, such as the fourth ventricle, the aquæductus Sylvii, and the upper part of the central canal of the spinal cord from a fall, for example, on the anterior and upper part of the skull. As all the spaces in the brain which contain cerebro-spinal fluid communicate freely, it is easy to understand that lacerations of the brain can take place in any direction in which the cerebro-spinal fluid is pressed.

Hence it is that we so frequently observe lacerations in various parts of the brain which do not correspond with the area directly affected by the traumatism. Duret has demonstrated this by experimental investigations.

The white matter is, generally speaking, more capable of resistance than the softer and more vascular gray matter. The most frequent contusions are those of the cortex, which may be either direct or indirect, and those of the walls of the fourth ventricle, which we have just explained. The medulla, crura cerebri, and pons are the least frequently the seat of contusions (Fano, Precott). Those of the cerebellum are also somewhat frequent, and involve almost always the under surface. The small hæmorrhages in the medulla and the walls of the fourth ventricle are of great importance, because here particularly vital portions of the brain are involved.

One sometimes finds at the autopsy of persons who have received an injury of the head from a fall, for example, extensive hæmorrhages within the brain and its membranes without injury to the cranial bones. In other cases there is a fracture of the inner table. In rare cases of concussion of the brain of this sort, with or without fracture of the skull, fatal cerebral hæmorrhage takes place after a comparatively long time, such as two to three weeks, or still later (traumatic apoplexy).

Wounds of the Brain.—Gunshot wounds of the brain take the form either of a perforation of the brain matter, usually with contusion on the opposite side, or of a grazed or furrowed wound. In perforating shots from one side of the skull to the other, fragments of bone of various sizes and particles of lead are almost always found along the course of the bullet. The walls of the gunshot canal are sometimes smooth and sharply defined, but more frequently the surrounding tissue is more or less contused. Foreign bodies, such as splinters of bone, pieces of lead, or bullets may heal up inside the brain (see page 134). The bullet may only apparently have entered the brain, but in reality rebounded after shattering the bone. In rare cases bullets have wandered about and reappeared at different parts of the body outside the cranial cavity. Neudörfer observed a spontaneous discharge of the bullet from the interior of the skull through a fistula that had remained open for three years. Bullets have also been known to escape from the cranial cavity and come out through the throat after causing a pharyngeal abscess. Small splinters of bone may become completely absorbed in time after they have healed up aseptically within the brain.

Incised wounds of the brain may be either linear wounds with or without contusion, or flap wounds, or wounds with loss of brain matter.

In some cases a portion of the brain with a covering of bone and soft parts is completely severed from the rest of the brain.

The punctured wounds of the brain which are made by a knife, dagger, bayonet, etc., are of special interest. These weapons either enter the brain through the orbit and nasal cavity, or directly through the cranial bones. The more pointed the instrument the slighter is the external injury. Not infrequently the point of the instrument breaks off and remains embedded in the bone or the brain. The foreign body may heal up within the brain, but the patient more frequently succumbs to meningitis or abscess of the brain.

Symptomatology of Injuries of the Brain.—The symptoms caused by the injury of the brain as such consist in corresponding functional disturbances of the injured portion of brain. While in simple concussion general symptoms affecting the whole brain are present, injury to a definite portion of the brain is followed by corresponding local disturbances or so-called focal symptoms which appear immediately after the injury. Hence the science of surgery is called upon to advance our knowledge of the localization of brain functions. A large percentage of all brain injuries causes no symptoms, because other parts of the brain assume the function of the injured portions. The principle of substitution is very perfectly developed in the brain, and particularly in the cerebrum. On the other hand, focal symptoms are often absent, because the injured portion of the brain has but a slight physiological importance. Very extensive injuries of both frontal lobes, with the exception of the third frontal convolution, and injuries of both lower temporal convolutions, may cause no symptoms, while injury to the motor area in the vicinity of the fissure of Rolando gives rise to motor paralyses.

Besides the focal symptoms in brain injuries, general cerebral symptoms are also present, depending upon concussion of the brain, and, moreover, symptoms of compression, especially in case of simultaneous intracranial hæmorrhage. These have been described in the sections on Concussion and Compression of the Brain (§§ 13, 14).

We shall next take up injuries of the various portions of the brain and medulla with reference to the resulting focal symptoms (see also § 12, Anatomy and Physiology of the Brain).

Injuries of the Cortex.—Injury to the upper and middle frontal convolutions is followed neither by motor nor sensory disturbances. On the other hand, temporary or permanent mental disturbances, especially dementia, have been observed after a lesion of both upper frontal convolutions. In the third frontal convolution is situated, as we have already seen, the motor centre for speech. A lesion of this

convolution therefore gives rise to a distinct form of disturbance of speech which we shall, with Naunyn, designate as motor aphasia, in distinction to other sensory forms (see Fig. 56, 3 ○, page 89). In this motor aphasia the patients, in spite of the fact that the muscles of speech are intact, are unable to form words because they have lost the conception, or, so to speak, the technique of word formation.

In motor aphasia the third left frontal convolution is usually injured, but it may also occur after a lesion of this same convolution on the right side. Right-handed individuals become aphasic from injury to the third left frontal convolution, and those who are left-handed from a lesion of the corresponding convolution on the right side. The more this or that cerebral hemisphere is used the more its functional power grows.

The other forms of aphasia will be taken up more fully later on.

The anterior and posterior central convolutions contain, as we saw above, the motor centre for the hypoglossus and facial nerves and the great motor area for the upper and lower extremities. Injury to the lowest portion of the anterior central convolution, just behind the third frontal convolution, causes paralysis of the facial and hypoglossal nerves (see Fig. 56, ⊖ ⦶). In injury of both central convolutions at about the middle of the fissure of Rolando the motor area for the upper extremity is affected (see Fig. 56, 4 ○). The motor area for the lower extremity is situated in the upper (median) portion, principally of the posterior central convolution as far as the upper parietal convolution (see Fig. 56 and Fig. 57 ●). In the upper or median portion of the anterior central convolution, or in the gyrus paracentralis, the two motor areas for the upper and lower extremity run into one another, and a lesion at this point may cause paralysis of both the upper and lower extremities (see Fig. 56 and Fig. 57 ◑).

We found that the centre for tactile and muscular sensation is situated in the vicinity of the interparietal fissure (see Fig. 56). Lesions of this portion of the cortex cause both paralysis of the so-called muscular sense, which is known as ataxia or disturbances of co-ordination, and changes in the tactile sense (diminution or increase of the same) with or without motor disturbances.

By ataxia we mean that condition in which the co-ordination of muscles necessary for carrying out a voluntary movement is disturbed, while the function and strength of the single muscles may be entirely intact. Besides this cortical ataxia we distinguish a spinal, bulbar, and cerebellar ataxia following injuries and diseases of the spinal cord, medulla, and cerebellum.

According to the location and extent of the lesion in the vicinity of

the interparietal fissure, there may be simple cortical ataxia or disturbances in the sensation of the skin of the extremities with or without motor paralysis varying in extent.

Injury to the anterior portion of the temporal convolutions causes no characteristic symptoms, while on the other hand the posterior two thirds of the upper temporal convolution contains a second speech-centre (see Fig. 56, 6 × × ×). Injury to this latter portion of the upper temporal convolution results in sensory aphasia with word-deafness—i. e., difficulty in understanding spoken words—or even complete word-deafness, although the hearing power as such is preserved.

Injury to the occipital lobe causes principally visual disturbances. As we saw above, the visual area is situated mainly in the vicinity of the calcarine fissure (Fig. 57).

The disturbances of vision which are known to occur in connection with lesions of the cortex are, according to Nothnagel, the following: 1, Hemianopsia; 2, total blindness; 3, color-blindness; 4, psychic blindness; 5, subjective sensations of light and visual images.

In hemianopsia there is loss of sight in the same half of the field of vision—usually the lateral half—in both eyes, so that they are incapable of receiving visual impressions. Total blindness, which was only observed in the case of double-sided lesions of the cortex, is to be looked upon as a bilateral hemianopsia.

In so-called psychic blindness the patient sees in the sense that he is capable of receiving visual impressions as such, but his memory images have been lost, and he is hence unable to interpret what he sees and turn it to any account mentally.

Colour-blindness occurs by itself, or combined with other visual disturbances.

Subjective sensations of light and hallucinations have been observed, particularly in progressive paralysis and in tumours and softening of the upper occipital convolution.

These visual disturbances, in consequence of lesions in the upper occipital convolution, are often found combined in various ways.

According to Nothnagel, the visual sense is localized in the occipital lobe in the following way: The cuneus and upper occipital convolution contain the area for visual perceptions, lesion of the same on one side causing hemianopsia, and on both sides complete blindness. The rest of the cortex of the occipital lobe contains the field of recollection of visual perceptions, and lesion of the same causes psychic blindness. It is still an open question whether this field of recollection of visual perceptions occupies only a part of the remaining cortex of the occipital lobe, and what part this is.

If the cuneus, the first occipital convolution, and the remaining cortex of the occipital lobe are affected on one side, and on the other the cortex of the occipital lobe, with the exception of the cuneus and the first occipital convolution, we shall have hemianopsia corresponding to the former side and psychic blindness corresponding to the latter.

Curschmann observed a very typical case which had almost the importance of a physiological experiment, and fully confirmed the above statements. The power of vision was lost in the left half of the field of vision on both sides, and the autopsy revealed a circumscribed area of softening in the tip of the occipital lobe, and, above all, in the entire extent of the cortical portion of the cuneus, resulting from an embolus of one of the three branches of the posterior occipital artery.

Finally, we have still to mention injury to the gyrus angularis. As we saw above, a third speech-centre is situated here in the vicinity of the visual centre, at the point where the posterior portion of the gyrus angularis becomes continuous with the occipital lobe (see Fig. 56, 11 +). A lesion at this point causes a particular form of disturbance of speech which is known as sensory aphasia with word-blindness (Naunyn), in which the understanding of written letters, syllables, and words is lost. This is not identical with word-blindness in general, any more than the hearing power as such is absent in auditory aphasia.

Localization of the Different Forms of Aphasia.—Naunyn, in particular, has rendered good service in the study of the localization of the forms of aphasia, and we are indebted to him for a very careful treatment of this subject.

We distinguish with him four main varieties of aphasia: (1) motor aphasia, (2) sensory (auditory) aphasia with word-deafness; (3) sensory aphasia with word-blindness; and (4) indefinite forms of aphasia.

By motor aphasia we understand that condition in which the patient is unable to form words—of course, not in consequence of paralysis of the muscles of speech. The memory-images necessary for word-formation are lost.

In sensory aphasia (Wernicke), or aphasia with word-deafness, there is difficulty in understanding spoken words, or even complete word-deafness—of course, with intact hearing power. Naunyn calls this auditory aphasia.

In the second form of sensory aphasia, or aphasia with word-blindness, the conception of written letters, syllables, and words is disturbed. This is, as has already been said, not identical with word-blindness in general, any more than the hearing power is absent in auditory aphasia.

The group of indefinite forms of aphasia includes, according to Naunyn, all those cases in which neither the difficulty in forming words nor the lost conception of words is the characteristic part of the disturbance of speech. The cases in this group are very varied: some present the picture of a marked paraphasia (confusion of words or syllables), others show a loss of memory for words (amnesia), and still others seem to be the same as Grashey's forms of aphasia—i. e., disturbances of speech in which the duration of the impressions made on the mind by different letters, syllables, and words is shortened.

Naunyn, by making use of the results of autopsies in seventy-one cases of aphasia, demonstrated that the area of motor aphasia is to be looked for in the third frontal or Broca's convolution (see Fig. 56 ○ ○ ○ 3), and that of sensory (auditory) aphasia in the posterior two thirds of the first temporal

convolution (see Fig. 56 × × × 6). In a case of auditory aphasia observed by Heubner the autopsy revealed a softening of a large part of the posterior portion of the first temporal convolution to such an extent that the latter had lost its connection with the cortex of the brain above, below, and behind. The majority of the indefinite forms of aphasia likewise depend, according to Naunyn, upon lesions of the third frontal convolution, or the upper temporal convolution; but in forty per cent of these indefinite aphasias these convolutions were found at the autopsy to be intact. A third area for a half of these cases of aphasia was found in the vicinity of the gyrus angularis, where it becomes continuous with the occipital lobe (see Fig. 56, 11 +). This area lies very near that of vision, lesions of which produce hemianopsia. Occasionally one also finds in aphasia, according to Naunyn, pathological changes in the portions of brain adjacent to these three above-mentioned areas.

These three areas of aphasia are intimately connected with the centres for the motor and sensory processes which play the most important part in speech:

1. Broca's convolution lies very near the centre for the muscles of speech —i. e., the centre for the hypoglossal and facial nerves (see Fig. 56, ⦶ ⊖).

2. Sensory (auditory) aphasia, with word-deafness, depends upon disturbances in the region of the posterior two thirds of the upper temporal convolution, where a centre for auditory perceptions is probably situated.

3. The other form of sensory aphasia with word-blindness is situated at the point of transition from the gyrus angularis to the occipital lobe—i. e., very near the centre for optic perceptions.

As regards the other focal symptoms in lesions of definite portions of the brain, the reader is referred to Nothnagel's work on the topical diagnosis of brain diseases. The following will suffice here:

1. Corpus striatum. In extensive lesions of the corpus striatum there ensues on the opposite side paralysis of the lower branches of the facial nerve, less frequently of the hypoglossus, the arm, leg, and muscles of the trunk, and the latter only to a mild degree. If the internal capsule is involved at the same time, the hemiplegia is permanent. If besides the motor hemiplegia there is hemianæsthesia, or if there are vaso-motor disturbances in the paralyzed parts, we have to do with a lesion in the posterior portion of the internal capsule. The paralyses which are caused by circumscribed injuries of the nucleus lenticularis or nucleus caudatus, or by a small lesion in the internal capsule, can disappear again completely.

Lesions of the centrum ovale are not followed by any characteristic symptoms.

2. Thalamus opticus. A lesion of the optic thalamus is probably present if there are visual disturbances (amblyopia on the opposite side or hemiopia on the same side) with peculiar motor disturbances (one-sided tremor, hemichorea, athetosis). Motor paralyses do not belong among the symptoms of lesions of the optic thalamus.

3. Corpora quadrigemina. The corpora quadrigemina have a direct connection with the optic and motor-oculi nerves; they form the first central area of vision. A lesion of the anterior pair is followed by a rapid diminution in the power of vision amounting even to blindness. It is particularly characteristic of lesions of this pair that the ophthalmoscopic examination is nega-

tive, and other focal symptoms are present. In lesions or injuries of the posterior pair there may be paralysis of the motor-oculi nerve, and particularly bilateral paralysis of its branches, without paralysis of the opposite extremities.

4. Crura cerebri. Lesions of the crura cerebri result in paralysis of the nerves of the extremities, the hypoglossal, facial, and trigeminal on the opposite side of the body, and, moreover, paralysis of all branches of the motor oculi on the same side.

Bergmann mentions a case observed by Pamard in which the point of a foil perforated the orbit of a supernumerary in a stage duel, whereupon he was immediately paralyzed on the whole of the left side. The autopsy revealed an almost complete division of the right peduncle.

5. Pons. In lesions of the pons, motor and sensory paralyses occur in the extremities on the opposite side, while the trigeminal, abducens, facial, and hypoglossal nerves may be paralyzed on the same side. In case of apoplexy (hæmorrhage and embolism), epileptiform convulsions often occur.

Lesions of the hippocampus, claustrum, and external capsule give rise to no symptoms of diagnostic importance.

6. Cerebellum. Lesions of the cerebellum, especially of the vermiform process, cause mainly ataxia (cerebellar ataxia), and disturbances of equilibrium in the form of vertigo and a reeling, staggering gait. These latter symptoms have been referred by many to injuries of the labyrinth following fracture of the petrous portion of the temporal bone. These disturbances of equilibrium are, moreover, not constant, and do not occur exclusively in diseases of the cerebellum. As a characteristic example of the development of disturbances of equilibrium after injuries of the cerebellum, a case observed by Friedberg may be cited. He found, after a depressed fracture of the right parietal bone, a softened area on the under surface of the left hemisphere of the cerebellum, with extension of the inflammatory process to the left pedunculus cerebelli ad pontem. The patient had suffered from severe attacks of vertigo, turning of the head, revolving in bed on the long axis of the body, etc.

7. Crura cerebelli. Revolutions on the long axis of the body are pathognomonic of lesions of the crura cerebelli as well as a characteristic immobility of the eyes, in which one eye is directed upward and inward, and the other downward and outward. If the connection with the cerebellum is not completely destroyed, and there are manifestations of irritation, the trunk, head, and eyes assume forced positions, and vertigo is present, combined both with the tendency to fall over on one side, and the above-mentioned revolutions on the long axis of the body. These symptoms result only from injury to the middle crura, and are absent in lesions of the anterior and posterior alone.

8. Medulla oblongata. Injury to the medulla may cause immediate death. As we saw above, in discussing the physiology of the brain (§ 12), the medulla contains in its formatio reticularis, corresponding to the tip of the calamus scriptorius, the centre for respiratory movements; and above this, likewise in the formatio reticularis, lies the centre for the innervation of the blood-vessels. Moreover, the medulla contains the inhibitory centre for the heart from which the heart's action is inhibited along the pneumogastric

nerve. Besides this, important transfers of centripetal stimuli into centrifugal ones take place here, giving rise to reflex movements.

Injury to these important centres causes corresponding functional disturbances, or death may take place immediately from paralysis of respiration or of the heart.

Injury to the bulbar portion causes hemiplegia alternans—i. e., motor paralysis of the extremities on one side and paralysis of sensation on the other. Injury to the pyramidal crossing by a needle in a one-year-old child was followed by complete paralysis of all the extremities, and death in fifty-eight hours (Kendrick). The child had fallen with a needle in its mouth, which pierced the uvula and posterior pharyngeal wall and entered the medulla in the median line.

Moreover, the peculiar disturbances of circulation and respiration (Cheyne-Stokes breathing) which appear from concussion of the brain are to be explained on the ground of involvement of these centres in the medulla. One finds in such cases injuries in the vicinity of the fourth ventricle, or hæmorrhages around the medulla.

In functional disturbances of the medulla, diabetes and albuminuria have also been observed. As mentioned above, Claude Bernard was the first to show that puncture of a certain portion of the fourth ventricle is followed by an alteration in the urine. If the floor of the fourth ventricle is punctured between the origin of the pneumogastric and auditory nerves at the apex of the calamus scriptorius, sugar appears in the urine (diabetes, mellituria). Puncture somewhat below the above-mentioned point causes polyuria without sugar (diabetes insipidus), and puncture above this point gives rise to albumin in the urine (albuminuria), the amount of urine remaining the same. Previous division of the splanchnic nerves makes Bernard's *piqûre* experiment impossible—i. e., diabetes does not follow.

In fact, injuries of the head, or rather medulla, due, for example, to a fall or blow on the head, especially the back of the head, are sometimes followed by glycosuria, polyuria, or albuminuria. But sugar appears in the urine not only after injury of the fourth ventricle or the vaso-motor centre, but after the injury of any nerve tracts which contain vaso-motor nerves. It has been found, for example, after division of the sympathetic (Pavy), after injury to the upper and lower cervical ganglia and the upper cervical ganglion of the sympathetic, after every section of the spinal cord as high up as the lumbar vertebræ, after stimulation of the depressor nerve (Filehne), after central stimulation of the pneumogastric, and finally after simply tying the animals down (cats, for example), as Böhm and Hoffmann have shown. According to this, it would seem as though diabetes were an affection of the vaso-motor nerves, and in fact tumours in the ependyma of the fourth ventricle have been found at the autopsy of diabetic patients (Bergmann, Mosler, Seegen, and others). Traumatic diabetes is usually only temporary, lasting, for example, for a few days only, but it may remain stationary, and is then usually combined with an increase in the amount of urine.

Unilateral injury of certain portions of the brain, especially the centre for muscular and tactile sensations in the neighbourhood of the posterior central convolution and the interparietal fissure, the pedunculus cerebri, the corpus striatum, thalamus opticus, cerebellum, and medulla, give rise to the

already mentioned forced movements. Of these anomalous movements three types may be distinguished: 1, Circular movements, when the movement takes place in the periphery of a circle; 2, rolling or screw movements—i. e., revolutions on the long axis of the body combined with translocation; and 3, clock-hand movements, in which the animal moves the front part of his body around the stationary back part. All those portions of the brain and medulla which in case of injury on one side show forced movements are directly concerned with locomotion (Steiner) and the abnormal movements are caused by a loss of the central motor innervation, or the indirect reflex innervation of one side, so that in consequence of the symmetrical arrangement of the body curvilinear movements will take the place of the normal movements in a straight line.

It is especially interesting to note the occurrence of lung affections which so frequently follow injuries of the head. They are in part broncho-pneumonias or aspiration pneumonias, caused by the entrance of particles of food into the respiratory passages during the act of vomiting, or of blood which flows down from the nose or mouth. Moreover, injury to the pneumogastric centre and paralysis of the recurrent laryngeal may have a part in the causation of these pneumonias. The above-mentioned foreign bodies (particles of food, blood, fluid from the mouth) may pass down into the lungs for the reason that the muscles that control the closure of the larynx and œsophagus are paralyzed, or because the parts in question are anæsthetic. Inflammations of the lungs may also be caused in injuries to the head by nervous disturbances without paralysis of the glottis. There may be, for example, a dilatation of the vessels in a larger or smaller lung area due to the injury, and in this way the portion of lung in question made less capable of resisting injurious influences (Falk, Flatten).

Occasionally one observes in injuries of the head a bloody, œdematous, flabby infiltration of the lungs, especially the lower lobes, which is probably caused by injury to the pneumogastric. The pneumogastric is, according to Schiff, Michaelson, and others, the vaso-motor nerve of the lungs, and its division gives rise to a neuroparalytic hyperæmia of the lung with œdema. Paralysis of the pneumogastric also causes a change in the innervation of the heart, which likewise brings about œdema of the lung.

Among other affections of the lungs, the migrating pneumonia following erysipelas of the head should be mentioned, which is caused by a spreading of the latter to the air passages, and, moreover, metastatic pneumonia in sinus thrombosis with pyæmia. Occasionally mild cases of fat embolism of the lungs result from fractures of the skull, and are caused by the passage of particles of fat from the brain or the diploë of the cranial bones into the capillaries of the lungs.

The further course of an injury to the brain depends upon whether or not vital centres have been invaded. If, for example, there is an injury to the centre that governs respiration and circulation, death follows immediately. If we disregard the physiological importance of the injured portion of the brain, the outcome of its injury depends mainly upon whether or not suppuration ensues, and with it the fur-

ther consequences—viz., suppurative meningitis, abscess of the brain, pyæmia, and septicæmia. Suppuration takes place mainly in the case of open wounds of the brain, because these, in consequence of their communication with the outside air, allow the entrance of germs into the cranial cavity. In all cases where foreign bodies have penetrated the brain and remained *in situ*—as, for example, in gunshot wounds, punctures, etc.—the danger of suppuration is particularly great, although it has frequently happened that even large foreign bodies have healed up within the brain without reaction, and been found accidentally at the autopsy years afterward (see page 134). In open wounds of the brain, which have healed aseptically, and especially in subcutaneous injuries, the injured area may heal with or without functional disturbances, depending upon its physiological worth. Even in cases of very severe and extensive injuries of the brain very surprising recoveries have been observed.

But, leaving suppuration out of consideration, the disturbances of circulation and the swelling in the injured area may cause death from compression, or œdema of the brain, especially if vital centres are in-

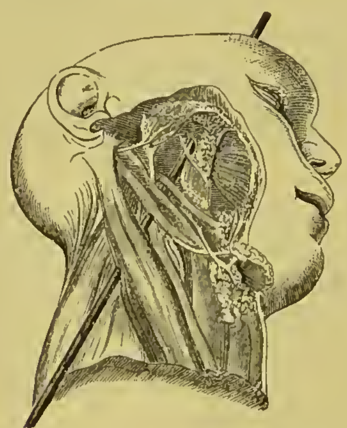


Fig. 65.—Penetration of the brain by a ramrod in a boy seventeen years of age; recovery (G. Fischer).

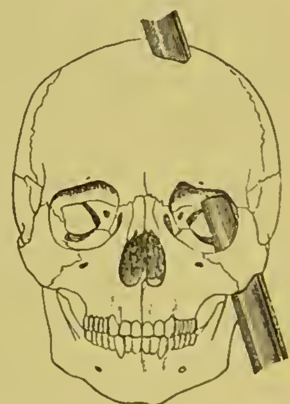


Fig. 66.—Injury of the brain caused by the penetration of an iron crowbar; recovery.

volved. The amount of circulatory disturbance and swelling depends mainly upon the extent of the injury.

Occasionally the course of a brain injury, especially gunshot wounds, is very protracted. Even after the lapse of years death may take place from abscess of the brain, which often develops very gradually.

On the other hand, very remarkable recoveries have taken place, particularly after gunshot wounds. Georg Fischer, for example, reported the following instance (see Fig. 65): A seventeen-year-old boy, while discharging a gun, was struck by an iron ramrod, which entered the back near the fourth dorsal vertebra, passed up along the thorax

on the right side of the neck, penetrated the skull and brain, and protruded thirty centimetres beyond the left side of the head. After making an incision in the neck the ramrod was driven back through the skull by means of a hammer, and pulled out through the wound in the neck. The patient recovered, except for blindness of the right eye.

The following case, observed in America, has also attracted a great deal of attention: A young man, while engaged in blasting, owing to the accidental explosion of the powder in the drill-hole, was struck by an iron crowbar three and a half feet long and one and a half inch thick, which passed through the head (see Fig. 66). After many ups and downs, due to inflammation, suppuration, and the discharge of necrotic splinters of bone, the patient was convalescent on the sixty-sixth day, and in several months had completely recovered.

Any one who is interested in rare cases of this sort will find a large collection in Bruns's work. In Fig. 36, page 49, is shown a healed gunshot injury of the frontal lobe of the brain.

According to Bergmann, among seventy-three cases of perforating gunshot injuries of the skull during the American civil war, fourteen recovered, but twelve of these suffered from serious brain affections, particularly disturbances of vision and partial paralyses, while all complained of headache, attacks of vertigo, and weakness of the intellectual faculties. Not infrequently epilepsy results from injuries to the brain and skull. Andrews has collected thirty-seven cases of gunshot injuries of the brain which recovered, of which, however, according to Bergmann, the diagnosis is certain in only fourteen.

Anatomical Changes in the Repair of Brain Injuries.—Degeneration and Regeneration of Injured Portions of the Brain.—Secondary Diseases.—The process of repair in brain injuries follows the general rules. As the result of my first investigations regarding the general process of wound healing I believed that in the cicatrization of brain injuries also the leucocytes took the most active part. After more recent investigations I am obliged to modify this view to some extent, and now believe that the white corpuscles undoubtedly take a part in the process, but that the cicatrix is formed mainly by the tissue cells, particularly the cells of the adventitia of the blood-vessels and the neuroglia. Hayem, Popow, Rudnew, and others have also demonstrated this. The nervous elements, such as the ganglionic cells, either take no part, or only a very insignificant one, in the process of repair. Spisharny's later investigations also show that the number of nerve cells which show karyokinetic changes in their nuclei is very small. According to him, the cicatrix following injuries of the brain is formed mainly by proliferation of the connective-tissue elements of the soft coverings of the brain.

The cicatrices in the brain, which consist of fibrillar connective tissue, sometimes radiate far beyond the site of injury into the normal brain tissue, and may lead to a progressive chronic interstitial encephalitis, with atrophy

of the nerve elements, so that increasing functional disturbances make their appearance at a comparatively late period after the injury. A similar traumatic proliferation of connective tissue (cirrhosis) takes place in the liver after a contusion. A case came under my observation in which two months after an injury there were several areas in which no normal liver tissue could be found.

Occasionally one finds after injuries of the brain, instead of a firm connective-tissue cicatrix, a delicate spongy tissue, whose meshes contain a yellow emulsive fluid.

Finally, one may find at the place of injury a more or less white, reddish-brown, or yellow softened area. In other words, owing to the swelling and œdema, or, in short, the temporary or permanent disturbance of circulation, mainly in the form of ischæmia, necrosis of the brain matter has taken place. The necrotic, softened tissue either remains white (white softening), or it becomes colored red, brown, or yellow, in consequence of hæmorrhages (red or yellow softening). Occasionally this softening, or necrosis, spreads, probably in consequence of a beginning fatty degeneration of the vessels, and may run a clinical course similar to abscess of the brain (Willigk, Bergmann). I trephined a characteristic case of this sort only a short time ago. In such cases the process of softening remains latent for some time—i. e., it causes no functional disturbances so long as portions of the brain of slight physiological importance are affected. If, however, vital portions of the brain, which can not be replaced by others, are attacked by the progressive necrosis, corresponding disturbances then arise in the form of paralyses or a sudden fatal coma.

The question of the regeneration of defects in the central nervous system is still an open one. Peripheral nerves are, it is well known, capable of very complete regeneration, as the success which has followed aseptic suture of divided nerves, with or without a loss of substance, shows. A defect in the human brain probably never undergoes regeneration; at least, so far as I know, it has never been observed. Voit observed regeneration in pigeons and hens after cutting away the cerebral hemisphere. As regards the capability of regeneration possessed by the spinal cord the views are divided. According to Schieferdecker, the regeneration of a defect in the spinal cord is impossible. Naunyn and Eichhorst, on the other hand, have observed regenerative changes in young puppies. Eichhorst demonstrated the possibility of regeneration of the nerve fibres, but considers the regeneration of ganglionic cells questionable. Brown-Séquard observed regeneration of the fibres and ganglionic cells of the spinal cord in young pigeons. In the human spinal cord, however, no regeneration, so far as I know, has ever been known to take place.

The later disturbances due to the secondary degeneration of nerve fibres which are cut off from their centre is also of great importance. Just as in the case of the peripheral nerves, the nerve fibres of the brain which are cut off from their centre undergo degeneration and die. In this way amyotrophic lateral sclerosis results from lesions in the anterior two thirds of the internal capsule (Türck). The progressive degeneration of fibres, which Charcot and Vulpian were the first to observe after injuries of the cortex in the region of the central convolutions, can be explained in the same way.

According to Flechsig, the fibres pass upward, as we saw, from the pyramids to the region of the central convolutions without the insertion of any gray matter. This anatomical fact is in harmony with that extensive descending degeneration of fibres which Duret, for example, observed in a dog nine months after destruction of a portion of the cortex. This involved the fibres of the crus cerebri, half of the pons, and the pyramid on that side, and the lateral columns of the spinal cord on the opposite side as far down as the lumbar segment.

Epilepsy and other Cerebral Disturbances following Head Injuries.—Epilepsy develops comparatively often after injuries of the head. It may be a reflex epilepsy, resulting from the injury of peripheral nerves in the soft coverings of the skull, or it may be due to changes in the cranial bones and the dura, and finally it may be caused by injuries of the brain itself, particularly of the cortex. If we disregard the reflex epilepsy due to the injury of peripheral nerves, the main cause of epilepsy is compression of the brain.

The epilepsy resulting from the injury of peripheral nerves in the soft coverings of the skull appears to be more common than that following the injury of other nerves. In such cases one often finds a sensitive cicatrix in the skin, after the extirpation of which recovery sometimes ensues. The latter is often only temporary, and after a longer or shorter period the epileptic convulsions return with renewed intensity.

Among the changes in the cranial bones which have caused epilepsy we may mention exostoses which project inward, or spicules of bone resulting from fractures of the skull, and finally firm adhesions between the dura mater and the inner table, all of which give rise to compression of the brain. In these cases the epilepsy may sometimes be cured by trephining the skull and removing the abnormal growth of bone, etc.

When due to injury of the brain, epilepsy has been observed most commonly after concussion of the brain with hæmorrhages into the medulla, and after injury to the motor areas of the cortex. Here also compression is the underlying cause. Westphal produced epilepsy experimentally in Guinea-pigs by repeated blows on the head. On the heads of such animals an "epileptogenic zone" developed some time later—i. e., an epileptic attack could be brought about by pinching or irritation of some sort. Westphal always found hæmorrhages in the medulla on post-mortem examination. Jacksonian epilepsy, which has often been observed and verified at the autopsy, is caused by irritation of the adjacent undisturbed motor area, and it is characteristic of this form of epilepsy that it always begins in certain groups of muscles, and that these groups are the ones most affected during the general convulsions and the period of unconsciousness that follow.

An injury to the head received in childhood is often overlooked in epilepsy. (For the surgical treatment of epilepsy see §§ 20 and 90, Ligation of the Vertebral Arteries.)

Previous injuries to the head are also of great etiological importance in the development of other cerebral disturbances. These are caused mainly by the diffuse degeneration of certain portions of the cortex, and we know how frequently the cortex is involved in injuries of the head. The psychosis either follows the traumatism or develops a variable length of time afterward, with or without prodromal symptoms. The psychosis is often tran-

sient, or it may be permanent, and not infrequently results in an incurable dementia. One usually finds in such cases atrophy of the cortex, or general atrophy of the brain, thickening of the soft coverings of the brain, and pachymeningitis. According to L. Meyer, of sixty cases of general paresis in the Hamburg Hospital, eleven developed after injury to the head.

It should, finally, be mentioned that traumatisms render the brain more sensitive and less capable of resistance, so that a sort of predisposition to psychoses is developed, which may then break out in consequence of some exciting cause.

The adhesions that sometimes form between the brain and its membranes, and between the latter and the bone after injuries of the skull, are of special importance. In such cases every change in position pulls on this portion of the brain, as well as the entire half of the brain. Such patients suffer particularly from attacks of vertigo, quick movements are impossible, and traumatic epilepsy is sometimes present. In case such patients are adapted to an operation, Macewen advises that it only be performed when no fever is present, and that in case of encephalitis it should be postponed (see also § 20, Surgical Treatment of Diseases of the Brain).

Healing up of Foreign Bodies in the Brain.—The most varied foreign bodies have healed up in the brain, such as splinters of bone, bullets, needles, points of instruments, etc. Bergmann mentions numerous instances. Bardeleben has seen bullets heal up within the brain under antiseptic treatment in three instances. Malle, Doutrelepont, Küster, and others have likewise seen bullets heal up within the brain. In Malle's case the ball was found in the left lobe of the cerebellum after a number of years of undisturbed health. Doutrelepont's patient died four and half years after the injury of pulmonary tuberculosis, and the bullet was found healed up in the falx cerebri, without having caused any focal symptoms on the part of the brain. Simon found, according to Bergmann, at the autopsy of a woman seventy-nine years old, a needle healed up in the brain, which had passed through the left hemisphere. The head stood upright and the point lay in the left lateral ventricle. The needle had probably been stuck through the anterior fontanelle at an early age, with murderous intent. Huppert found in the case of a forty-two-year-old man, who had been insane for a year, a slate pencil three inches in length in the white matter of the brain, just below the floor of the posterior and inferior cornu of the lateral ventricle. It may have passed through the posterior fontanelle at the apex of the occipital bone and healed up in the brain without causing any symptoms. Hodge found, at the autopsy of a man, a needle which had healed up in one of the hemispheres of the brain, parallel to the longitudinal sinus. In this case, also, no symptoms whatever were present during life.

Treatment of Brain Injuries.—The treatment of brain injuries should be, above all, prophylactic—i. e., one must try to prevent the occurrence of inflammation and suppuration in the wound in the brain. All wounds of the head that may be present, such as compound fractures of the skull, should therefore be treated according to strict antiseptic rules as described above (§ 2 and §§ 7–9). Open wounds of the brain

are likewise disinfected by many surgeons with 1-to-1,000 bichloride or three-to-five-per-cent carbolic; an eight-per-cent solution of chloride of zinc also causes no reaction (Socin). I prefer irrigation with sterilized water, or at most three-per-cent boric-acid solution. In case symptoms of compression are present, caused, for example, by hæmorrhage from the middle meningeal artery, trephining is indicated. Trephining is, on the contrary, useless in case of extensive hæmorrhages beneath the dura and inside the soft coverings of the brain. Moreover, trephining is indicated in circumscribed comminuted fractures of the skull with depression, because in these the splintering of the inner table is probably always more marked and more detrimental to the surface of the brain. It is hence made use of in comminuted fractures from the blow of a hammer, in gunshot fractures, and in incised and punctured wounds. In such cases we trephine not on account of the depression that is present, but on account of the splintering of the bone, resulting sometimes in laceration of the brain by fragments of bone which must be removed. The splinters of bone are sometimes so deeply embedded in the brain that they can not be reached. In comminuted fractures that extend over a large area the spicules of bone are, generally speaking, less frequently driven into the brain than in circumscribed comminuted fractures with depression. In compound comminuted fractures, however, which cover a considerable area, it is, of course, often advisable and necessary to remove the fragments in order to expose the wound in the brain more completely and disinfect it.

In all these cases one should of course trephine only when localized cerebral symptoms point to the existence of a corresponding injury of the cortex. Any bullet that may have entered the brain should be removed only in case it can be seen, and it is a bad plan to search for it too long. For the technique of trephining and temporary resection of the skull the reader is referred to § 23. One will also find there (Figs. 79, 80) the topography of the cortical areas and of the most important fissures and convolutions, with their relations to the cranial bones and sutures.

§ 18. **Traumatic Prolapse of the Brain.**—Prolapse of the brain matter is most commonly observed after compound fractures, particularly gunshot fractures with laceration of the brain, and in other fractures with a small loss of bone; also after trephining, and more rarely after the formation of extensive defects in the bone. The lacerated brain matter can protrude through the wound immediately after the injury and escape. In this way large portions of the brain may be lost, as in a case reported by Lücke, which afterward recovered, although the greater part of the temporal lobe had disappeared.

In other cases the prolapse does not occur until later, in consequence, for example, of œdematous swelling of the brain. The size of this later prolapse of the brain is subject to great variations; it may be very small at the beginning, and gradually grow to the circumference of a man's fist.

Prolapse of the brain occurs most frequently on the convexity of the skull, but it may take place through the ear or the orbit. Occasionally the ventricle within the prolapsed portion of brain opens externally, so that a clear fluid escapes continuously (Baum, the author).

The cause of prolapse of the brain is, generally speaking, an increase in the intracranial pressure due to a serous infiltration of the portion of brain immediately affected or its surroundings, or it may be due to a focus of softening or an abscess. The beginning of a prolapse may be favoured, or the size of the same increased by excessive crying aloud.

The prolapsed brain is not covered by the dura. The latter is either opened at the time of injury, or in the case of a prolapse that takes place later on it gradually disappears. The prolapsed portion pulsates perceptibly, especially at first; but later, after it has reached a certain size, the brain pulsation ceases. The prolapsed brain can be pushed back in place only at the beginning, but pressure of this sort causes vertigo, nausea, and slowing of the pulse.

Fig. 67.—Prolapse of the brain (encephalocele) following a gunshot injury (Podrazki).

Prolapse of the brain should not be confused with those fungous protrusions of blood clots occurring in injuries to the dura and the brain; nor with exuberant granulations which appear in the subsequent course of healing of head injuries; nor, finally, with new growths, especially medullary tumours of the bone or brain membranes.

The further course of prolapse of the brain varies. Large prolapsed portions usually become gangrenous at last, and after the necrotic portion has come away the rest may become smaller and smaller and finally disappear completely. Less frequently the prolapsed portion of brain, which has become stationary in size, is gradually covered over with skin—i. e., a hernia of the brain, or encephalocele, remains behind (see Fig. 67).

The prognosis of prolapse of the brain under antiseptic treatment is more favourable than formerly, when fatal meningitis occurred with comparative frequency. In the American civil war, out of forty-three

cases, only seven, according to Bergmann, recovered. Bergmann has collected in all fifty-four cases of recovery from prolapse of the brain. Very often the injury as such is severe enough to cause death.

The treatment of prolapse of the brain must be governed in every case by antiseptic rules. In fresh cases of injury to the head, with exposure of the brain or escape of brain matter, one must see to it by means of strict antisepsis that inflammation and inflammatory swelling of the brain, potent factors in the causation of prolapse, are avoided.

Likewise in the prolapses that develop later, meningitis especially should be prevented by antiseptic treatment. By means of ice and cathartics the prolapse can be diminished in size. Dressings that exert pressure are not to be recommended, but, on the contrary, the antiseptic protective dressing should be applied in such a way that the prolapsed portion is protected from all pressure. This may be accomplished by putting on a ring of cotton, for example. In this way disturbances of circulation within the prolapsed portion of brain are avoided and it can gradually diminish in size. In any case one should not immediately cut away the prolapsed portion of brain, but treat it expectantly in the way described above, and see whether it does not disappear of itself. In suitable cases the prolapse may be covered with skin flaps or cicatrization promoted by means of Thiersch's skin-grafting; or, finally, the defect in the bone may be closed with pedunculated flaps of skin, periosteum, and bone after König and Müller, by means of a celluloid plate after Fränkel, or by decalcified bone plates after Senn (see also page 55).

§ 19. **Inflammations of the Membranes and Sinuses.**—I. *Inflammation of the Dura* (*Pachymeningitis*).—Pachymeningitis is mainly localized either on the outer or the inner surface of the dura. The first form is called external pachymeningitis or endocranitis, and the latter internal pachymeningitis. Either form may give rise to the other.

Suppurative external pachymeningitis or endocranitis is most commonly the result of compound fractures of the skull and of inflammation and suppuration in the neighbourhood, especially acute and chronic suppuration in the tympanic cavity. (For a description of syphilitic endocranitis the reader is referred to § 11.) Suppurative endocranitis is usually combined with cellulitis, suppurative periostitis, inflammation of the soft coverings of the brain, or with encephalitis. When it is present alone, symptoms of compression, with fever, may exist in case sufficient pus collects between the bone and dura.

In the majority of cases suppurative pachymeningitis spreads and gives rise to leptomeningitis, sinus phlebitis, and abscess of the brain, and in fact these latter diseases find their most frequent cause in

suppurative pachymeningitis. The development of suppurative endocranitis is favoured by the infection of external injuries and by the retention of pus, particularly in suppurative processes in the middle ear. Suppuration may also spread from without to the cranial cavity along the canals for the vessels and nerves, causing a suppurative osteophlebitis, and, moreover, by means of carious processes, such as caries of the petrous portion of the temporal bone in disease of the middle ear. As regards suppurative external pachymeningitis following inflammations of the middle ear, Hoffmann has collected one hundred and two post-mortem cases, and these show that it is the most frequent intracranial disease following otitis media, and runs its course in the way described above.

The treatment of suppurative pachymeningitis consists mainly in providing for a sufficient escape of the pus—if necessary by resection of the bone with the chisel, or, in case there is already a hole in the bone, by means of rongeur forceps. As far as prophylaxis is concerned, the rule holds here also to treat every head injury on antiseptic principles. If in conjunction with suppuration in the middle ear, tenderness over the mastoid process, headache, fever, stupor, or symptoms of beginning meningitis or sinus thrombosis make their appearance, one should think of suppurative endocranitis, and immediately open the mastoid process (see § 78).

Among chronic inflammations of the dura, tuberculosis and syphilis are the most common. Only the circumscribed tubercular and syphilitic inflammations can give occasion for surgical interference. Gussenbauer cured in a young man twenty-one years of age a circumscribed tubercular pachymeningitis by operative measures.

Internal pachymeningitis belongs less in the province of surgery than in that of internal medicine, to the text-books of which I hence refer. I mention here only the hæmorrhagic infiltration of the inner surface of the dura, pachymeningitis hæmorrhagica, which sometimes gives rise to marked hæmorrhages or so-called hæmatomata of the dura. In rare cases localized collections of serum are found on the inner surface of the dura, which are known as hygromata of the dura.

Suppurative internal pachymeningitis is secondary either to suppurative external pachymeningitis, or to inflammation of a sinus, or to suppurative inflammation of the soft coverings of the brain (leptomeningitis).

II. **Inflammation of the Dural Sinuses** (*Phlebitis sinum duræ matris; Colpitis cerebralis*).—Inflammation of a sinus is caused by the extension of a neighbouring inflammatory or suppurative process, or by primary infection of a thrombosed sinus after compound fractures of the skull, for example. The lateral sinus is the most frequently diseased, in consequence of inflammatory processes in the middle ear and

the mastoid process, caries of the petrous portion of the temporal bone, and subdural suppuration; next in frequency comes inflammation of the cavernous sinus, and somewhat more rarely of the longitudinal sinus, in consequence of compound fractures of the skull.

About two thirds of all cases of sinus phlebitis have their origin in inflammation of the ear. The inflammation sometimes spreads to the internal jugular vein. Sinus thrombosis is very frequently combined with suppurative inflammation of the dura and the soft coverings of the brain, and also with brain abscess. Caries of the cranial bones occasionally causes an opening into a sinus, and gives rise to hæmorrhage, which is usually easy to arrest by pressure.

The symptoms of inflammation of a sinus are seldom present alone, but are combined with manifestations due to injury or disease of the membranes, brain, middle ear, mastoid process, etc.

The symptoms due to inflammation of a sinus are partly cerebral and partly a result of the pyæmia. The cerebral symptoms consist mainly of irritation and compression (headache, vomiting, choked disk, delirium, stupor). There is usually a high temperature, and in pyæmia an irregular intermittent fever with chills. It is important to remember that there is an otitic pyæmia without sinus thrombosis. Death occurs either suddenly with coma, convulsions, and symptoms of paralysis, or more slowly with the manifestations of pyæmia. The symptoms also vary with the location of the inflammation. Inflammation of the cavernous sinus is characterized by ocular disturbances (congestion and inflammation of the veins of the eye, paralysis of the third and fourth cranial nerves and the first branch of the fifth, which lie in the vicinity of the sinus). In consequence of hæmorrhages within the soft membranes of the brain, near the origin of the hypoglossal nerve, in conjunction with inflammation or thrombosis of the cavernous sinus, impairment of the mobility of the tongue has been observed.

In inflammation of the lateral sinus we have, besides the symptoms of inflammation of the middle ear and mastoid cells and caries of the petrous portion of the temporal bone, with or without facial paralysis, the manifestations of a subdural abscess (deep-seated headache, choked disk, etc.). Symptoms of irritation or paralysis of the pneumogastric nerve, with slowing or quickening of the pulse, are sometimes present. Paralysis of the spinal accessory and hypoglossal nerves has also been observed (Beck).

Forselles collected from literature one hundred and thirty-nine cases of thrombosis of the lateral sinus due to middle-ear disease, among which sixty-seven were uncomplicated, twenty-seven were complicated with meningitis, thirteen with cerebral abscess, and fifteen with both

together. This valuable collection of cases demonstrates how often the typical picture of sinus thrombosis is altered as regards cerebral, pyæmic, and other symptoms. The symptoms of inflammation of the superior longitudinal sinus are the least characteristic, the manifestations of meningitis and encephalitis being most prominent.

The prognosis of sinus phlebitis is bad in itself, but it also depends largely upon the cause. Thrombosis of a sinus is not in itself as dangerous as at one time supposed; it causes no functional disturbances, and is really a protection against general infection. The danger comes from suppurative breaking down of the thrombus. Extensive purulent inflammations of a sinus, probably without exception, prove fatal from meningitis, encephalitis, sepsis, or pyæmia.

The treatment of sinus inflammation is first of all prophylactic. Every head injury must be treated antiseptically, and when pus is present it should be evacuated by an early incision and the suppurative process checked by an antiseptic after-treatment. Above all, suppuration of the middle ear and mastoid abscess must be treated in the proper way (see Surgery of the Ear). The cause of the sinus inflammation must be sought for and treated in every case; a subdural abscess must, for example, be evacuated by opening the skull, etc. The treatment of an already existing sinus inflammation is, when possible, an operative one, such as Zaufal, Lane, Ballance, and others have recommended and successfully made use of in several cases. I should also recommend exposing the lateral sinus in a case of otitis media with the above-described cerebral and pyæmic symptoms, inserting an aspirating-needle if necessary, and when pus is found, opening it and packing it. In such cases the mastoid process should be freely opened (see § 78), and then the sinus or subdural abscess exposed and treated. The internal jugular vein should be ligated in many cases before or after opening the sinus, especially if the latter is filled with a putrid material. Körner collected twenty operated cases of sinus phlebitis following ear disease, of which thirteen were cured. Out of eight cases in which the internal jugular was not tied four recovered, and out of twelve cases in which it was tied nine recovered. In four of these last cases the vein was tied before the sinus was opened, and scraped out, and all four recovered. Forselles's statistics also show that the internal jugular should always be tied. In case of thrombosis of the cavernous sinus, Laucial recommends immediate enucleation of the bulb on that side, followed by a thorough scooping out and disinfection of the orbit as far as one can reach.

Unfortunately, one's operative measures often come too late, as it is not easy to choose just the right moment for surgical interference.

III. **Inflammations of the Soft Coverings of the Brain** (*Leptomeningitis*).—Of the inflammations of the soft coverings of the brain, we shall consider mainly acute traumatic suppurative inflammation.

Acute traumatic suppurative meningitis is either primary or secondary.

Primary meningitis following perforating injuries of the skull is caused by pyogenic organisms which have entered the interior of the cranial cavity in consequence of division of the covering of soft parts and bone on the convexity and base of the skull. After fractures of the base the microbes find an entrance into the cranial cavity through the cavities of the face and skull, such as the nose, the frontal and sphenoidal sinuses, and the tympanic cavity.

Secondary meningitis is due to the spreading of an inflammation and suppuration on the skull, such as a diffuse cellulitis, suppurative phlebitis or erysipelas of the soft parts, suppurative periostitis and osteomyelitis of the cranial bones, sinus thrombosis, etc. The inflammation either spreads by contiguity—i. e., the microbes pass along the veins through the intact bone into the cranial cavity, or they are carried by the lymph stream, since, according to Schwalbe, the lymphatic system of the outer coverings of the skull communicates with that inside the cranial cavity. The lymph stream passes, as is well known, from the outer coverings of the skull through the bone into the lymph spaces, between the bone and the dura, and from here the lymphatics penetrate the dura and enter the subdural space. Inflammation can also spread along the main nerves from the outer surface of the skull into its interior, particularly along the optic, facial, auditory nerves, etc. Meningitis may furthermore result from the gradual advancement of a brain abscess toward the surface of the brain.

Finally, mention should be made of metastatic suppurative meningitis in the course of pyæmia caused by microbes which are brought by the circulation from some focus of infection.

The anatomical changes in acute suppurative meningitis are, generally speaking, those of a diffuse phlegmon of the cranial cavity. The suppurative exudate is found in the parenchyma of the soft coverings of the brain, where the pus mainly follows the vessels. In the initial stages the pia is cloudy in appearance, and then a gelatinous coating is formed, which finally takes on a plainly purulent character. The cerebro-spinal fluid is cloudy, and later contains distinct flocculi of pus. The inflammation is either confined to the place of injury or it progresses and gives rise to a diffuse suppurative inflammation, which spreads from the convexity of the brain to the base, or *vice versa*, and may extend as far down as the cauda equina of the spinal cord. The brain itself is likewise always involved in suppurative meningitis, the suppuration spreading mainly along the vessels of the pia into the brain

matter and causing a corresponding softening of the parenchyma and granular degeneration of the ganglionic cells.

Symptomatology and Treatment of Suppurative Meningitis.—Primary traumatic suppurative meningitis usually appears very soon after the injury, most commonly on the second or third day, or later, from the fifth to the eighth day. As we have already mentioned, Bergmann found, thirty-six hours after a gunshot injury of the skull, a suppurative meningitis which had spread from the convexity of the brain to the cauda equina. Secondary suppurative meningitis is the slowest in developing, and is usually found localized around necrotic bone or separated fragments.

The symptoms of acute suppurative meningitis following, for example, a compound fracture of the skull are somewhat as follows: A marked chill only rarely precedes the disease, but usually the temperature rises slowly while the pulse becomes weak and rapid. Vomiting is a frequent symptom. Manifestations of congestion of the brain then become prominent, especially headache, increasing restlessness, and delirium. The patients toss about in bed, groan, and grind the teeth together. The pupils are at first contracted, then later become dilated and react to light.

Especially in unconscious patients the preliminary stage is very much obscured, and the rise of temperature and beginning manifestations of congestion are the first signs that call attention to a commencing meningitis.

The stage of restlessness is often very short, and may, in fact, be absent altogether, so that the most important symptom, and the one which decides the diagnosis—viz., the paralyses—appears very early.

The paralyses, which are usually unilateral, are probably caused by a successive loss of function of the cortex in consequence of changes in the brain matter due to the suppuration—i. e., suppurative encephalitis with softening and granular degeneration of the brain matter, especially the ganglia.

Clonic muscular contractions of the face, for example, or the extremities, are, generally speaking, of rare occurrence in traumatic meningitis and are most frequent in children.

At the last the patients become more quiet and somnolent, and die with symptoms similar to those in compression—i. e., the rapid pulse becomes progressively weaker and the respiration more and more irregular.

In basal meningitis following fractures, for example, in this region, the unilateral paralyses are absent, but the other symptoms are the same as in meningitis of the convexity. It is important to note in

basal meningitis the paralyses of the nerves in this region, especially the facial, abducens, and motor oculi, which are caused partly by the inflammation that has spread to them and partly by the pressure of the suppurative exudate or of the congested lymph in their sheaths. Occasionally paralyses of this sort—for example, of the facial nerve following fracture of the petrous portion of the temporal bone—are the forerunners of a meningitis which develops from extension of the inflammation along the facial nerve into the cranial cavity.

Rigidity of the back of the neck is very often present in basal meningitis, being due mainly to irritation of the spinal cord (Leyden).

The prognosis of diffuse suppurative meningitis is hopeless, and death usually takes place within the first three days.

In the treatment of acute suppurative meningitis, prophylaxis is in the first place of the greatest importance. This means that by our strict antisepsis we are to avoid inflammation and suppuration in all wounds and compound fractures. If diffuse suppurative meningitis has once broken out, all therapeutic measures are probably without avail. The treatment is then symptomatic and is directed mainly against the cerebral manifestations. It is, generally speaking, the same as in cerebral compression (see § 14).

As long as the meningitis still remains localized it would perhaps be possible to prevent its further extension by opening the cranial cavity and treating locally the infected or inflamed area. But, unfortunately, as soon as the diagnosis of meningitis has been made it has already extended so far that trephining can do no good. Bergmann is right when he recommends trephining only for those cases of suppurative meningitis which are caused by a brain abscess reaching the surface of the brain. In such cases it is perhaps possible to prevent further extension of the beginning meningitis by opening the cranial cavity and providing for an escape of the pus. Usually, however, trephining is undertaken too late, so that in these cases also the patient can not be saved. For a description of puncture and drainage of the lateral ventricles for tubercular meningitis the reader is referred to page 151.

§ 20. **Diseases of the Brain (Abscess, Tumours, Epilepsy, etc.) and their Surgical Treatment.**—The surgical treatment of brain diseases, especially abscess, tumours, and epilepsy, has been developed principally by Bergmann, Horsley, Macewen, Reid, Keen, Anderson, Broca, Weir, Lannelongue, and others. Bergmann's excellent monograph may be recommended for a careful study of this subject. We shall take up first brain abscess.

I. **Abscess of the Brain.**—Cerebral abscess is either acute or chronic. Its causes are very varied, and it may develop partly as the result of

injuries and partly of diseases in the immediate vicinity, such as syphilis, tuberculosis, etc., and particularly suppuration in the middle ear. In some cases it has been due to metastasis. Abscess formation due to primary actinomycosis of the brain was first described by Bollinger.

Acute traumatic abscess of the brain takes the form either of a diffuse septic suppuration with rapidly fatal meningitis which develops within the first few days, or of a more circumscribed suppuration which appears later in the injured portion of the brain after open wounds of the same. Both forms usually prove fatal from meningitis within the second or third week. If meningitis does not develop and the pus escapes externally, recovery is possible by the formation of granulations and a cicatrix in the injured portion of the brain.

In other cases the acute traumatic brain abscess passes over into the chronic form by the pus focus becoming encapsulated. This brain abscess can then gradually extend and suddenly prove fatal after months or years in case an important brain area becomes involved. Most chronic abscesses of the brain develop beneath suppurating compound fractures of the skull, and after suppurative inflammation of a contused wound of the cortex, and also within the substance of the brain by metastasis, without the existence of a brain injury.

Metastatic brain abscesses are often multiple. They develop in connection with pus foci in different organs, such as the lungs, liver, spleen, and heart. Martius collected from literature twenty-two cases of embolic abscess of this sort, and it was shown that they develop with preference in the region of the left middle cerebral artery.

Abscesses of the brain are most frequently the result of chronic suppuration of the middle ear. In some cases the suppurating area within the cranial cavity is continuous with that in the tympanic cavity or the mastoid process—i. e., the pus collects between the dura and bone, and then in and beneath the dura and within the temporal lobe of the brain. Frequently, however, pus forms within the brain at some distance from that in the ear. If in chronic suppuration in the middle ear fewer irrigations were made and more attention paid to a free escape of the pus, brain abscesses would be of less frequent occurrence. In suppurative processes in the tympanic cavity or the mastoid process the brain abscess is usually found in the middle fossa, or, in other words, the temporal lobe, while in suppuration within the labyrinth the cerebellum is principally affected (McBride, Miller). According to Barr, out of seventy-six cases the abscess was found fifty-five times in the temporal lobe, thirteen times in the cerebellum, four

times in both of these places at once, twice about the occipital protuberance, and once in the pedunculus cerebri.

The growth of a chronic brain abscess which is usually inclosed in a so-called abscess membrane is very variable. The thicker and firmer the encapsulating membrane, the slower the growth of the abscess. Its growth also varies at different times, and corresponding to these changes the inflammatory symptoms become more or less prominent. The abscesses are located either in the cortex or the deeper parts. Their size is very variable; abscesses the size of a pigeon's egg which have existed for years are not very rare, while suppuration of one or even both lobes of the brain has been demonstrated at the autopsy. In consequence of further growth, the chronic abscess finally ruptures into a ventricle or comes to the surface of the brain.

In case the abscess ruptures into the ventricle, death usually ensues very quickly with general convulsions or a deep coma of short duration. If it breaks through the surface of the brain it becomes fatal from diffuse meningitis. In exceptional cases brain abscesses, after the formation of adhesions between the membranes of the brain and the bone, may gradually rupture externally.

The duration of an acute brain abscess is a matter of weeks only—usually from two to five—while that of the chronic form is very variable and it may last for weeks, months, or even years. Chronic brain abscesses of from ten to twenty years' standing have been observed.

The symptoms of a brain abscess are those of suppuration together with increased intracranial pressure and the focal manifestations depending upon the location of the abscess. It is of special importance to note occasional rises of temperature with intervals of no fever and an often sharply localized headache—for example, in otitis media.

The headache is usually made worse by percussing the portion of skull in question. The symptoms of compression are rarely so well developed as in tumours, and choked disk is usually not present. The focal symptoms due to the destruction of brain matter vary with the location of the abscess, and they may be absent altogether when, for example, the abscess is situated in the frontal or temporal lobe of the brain. The diagnosis is easiest when an open wound of the head is still present and pus oozes out through the cleft in the bone. Frequently, however, the diagnosis, particularly of an acute brain abscess, is impossible, and it can not be distinguished from suppurative meningitis, for example, or sinus thrombosis.

It is easier to make the diagnosis of chronic brain abscess which is characterized by a period of good health following the primary cerebral manifestations due to the injury. This latent period can then

afterward become interrupted occasionally, or more and more frequently, by different cerebral symptoms, such as headache, vertigo, nervous irritability, etc. As soon, however, as vital portions of the brain have become involved, or the abscess ruptures into a ventricle or reaches the surface of the brain, the above-mentioned symptoms suddenly appear, followed, it may be, by sudden death. In chronic brain abscesses following, for example, suppuration in the middle ear a subnormal temperature and pulse are often present.

The deep brain abscesses are often impossible to diagnose; their presence can sometimes be assumed only from their indirect influence upon cortical areas in the vicinity. For the diagnosis of every brain abscess the etiology is an extremely important factor.

The treatment of an abscess of the brain consists in prompt evacuation of the pus by trephining or temporary resection of the skull. *Ubi pus ibi evacua.* Metastatic and tubercular abscesses are not suitable for operative treatment.

Operation is principally indicated in the unilocular form of abscess without complications that are in themselves dangerous to life. According to Beck's statistics, among seventy-six operated cases, forty were cured; but in reality the prognosis is not so favourable as this, because the cases that result fatally after the operation are often not published. In every case the exact location of the abscess should first be determined, and then the skull opened at a corresponding point. In the case of the most frequent form of brain abscess—viz., that resulting from middle-ear or mastoid disease—the following points should be considered (McBride, Miller): If the auditory nerve is intact, the abscess is very probably in the neighbourhood of the tegmen tympani, and is most likely to be reached by opening the skull somewhat above and in front of the bony external auditory meatus. The skin incision should be made in such a way that through it the mastoid process can be chiselled open. If, on the contrary, the conduction of sound by means of the bone is absent, and hence the auditory nerve is involved, the pus will be found beneath the tentorium cerebelli, and the posterior fossa of the skull should therefore be opened. In brain abscesses due to middle-ear disease, where there is a primary pus focus in the temporal bone, or a fistula, the skull should be opened at this point. Generally speaking, I agree with Schede, Beck, and others in first opening the mastoid process down to the dura; from here any abscess in the temporal lobe or—behind near the posterior boundary of the mastoid process—any abscess in the cerebellum can be opened. This affords the best means of exit for the pus. Protective measures for the resulting cicatrix are unnecessary. Among fifty-five cases of otitic

brain abscess that were operated upon, twenty-nine recovered and twenty-six died.

After opening the skull for brain abscess by means of the trephine or chisel, the dura is found to be either normal or occasionally softened and discoloured. Pus may be suspected beneath the dura in case the latter is tense and pulsation is absent in consequence of anæmia of that part of the brain (Braun). There may, however, be pus beneath the dura, even though the dura be not tense, the surface of the brain not anæmic, and pulsation be present. The dura should therefore be opened in every case. Should no pus be found beneath the dura, the brain itself should be punctured with a medium-sized needle in case one is sure of the diagnosis. Renz evacuated the pus successfully with a fine aspirating needle. There is the danger in aspiration that the abscess will not be completely emptied, and, on the other hand, Pingaud saw fatal apoplexy result from too violent aspiration. Generally speaking, it is a good plan to open the abscess freely. Sterilized salt solution or two- to three-per-cent boric acid should be used for irrigation of the cavity. The wound should be kept open long enough under strict aseptic precautions, by means of a drainage-tube or gauze-packing, to prevent a reaccumulation of pus. Epilepsy has been observed to follow the operative treatment of brain abscesses in consequence of the formation of a cicatrix.

II. **Brain Tumours.**—Tumours of the brain are, generally speaking, but slightly suited to an operative treatment, and the latter should come into consideration only in the case of circumscribed tumours which can be completely removed. Of one hundred brain tumours collected by White, only nine, according to Bergmann, were operable. Starr analyzed three hundred cases of tumours occurring in young persons, and came to the conclusion that only six could have been operated on successfully. Definite clinical symptoms, such as focal manifestations, are often wanting. The amount of compression depends mainly upon the size of the tumour and the rapidity of its growth. Operations upon large tumours, even when well encapsulated, are particularly dangerous on account of hæmorrhage and the œdema of the brain due to the removal of large portions of the skull. The possibility of operative treatment of a brain tumour depends upon three circumstances: 1, a sure diagnosis of its location; 2, the possibility of reaching this locality after it has been determined; and 3, the pathological nature, circumscribed character, and size of the tumour. Cysts, echinococcus cysts, cystosarcomata, gliomata, sarcomata, and gliosarcomata are most suited to an operation, while the views as to its utility in tuberculosis and gumma formation are still divided. Bergmann, for example, is not in favour

of it in these latter conditions. Carcinoma is also to be excluded. Echinococcus cysts occur, according to Frey, in nine per cent of all cases in the cranial cavity, and it is comparatively rare for the brain to be involved. Steffen and Goldenberg collected twenty-one cases of echinococcus cyst of the brain. As far as the localization of the tumours is concerned, they have been found in all portions of the brain, particularly in the cerebellum, where, according to Starr, operation for their removal has always resulted fatally. In operating for tumours of the cerebellum, the tumour was in many cases not found; among thirteen cases cited by McBurney and Starr, this occurred six times.

For a purely cortical or epicortical location of a tumour the following symptoms are, according to Weir and Séguin, of diagnostic importance: Localized clonic contractions, epileptiform attacks beginning with local spasms and ending in paralysis, the early appearance of localized pain and tenderness on the skull, and increased temperature of the portion of the skull in question. The subcortical location of a tumour is indicated by a limited or half-sided paralysis followed by contractions, a preponderance of clonic spasms, the absence, slight degree, or late appearance of localized headache and tenderness on percussion, and, finally, a normal temperature over the area in question.

Although we are still obliged for the present to assume an expectant attitude as regards the surgical treatment of tumours of the brain, yet one should not deny the possibility that here also in the future our operative technique will bring about more encouraging results than has been the case in the past. Results such as Horsley, Weir, Séguin, Keen, Bramann, and others have to show, encourage further attempts. Bergmann collected twenty cases of brain tumours, including gummata and tuberculosis, which were operated upon with very variable success. Most of the patients died as a result of the operation, while among the successful cases were those operated on by Durante, Horsley, Keen, Bramann, Weir, Séguin, and others. According to Beck's recent statistics, among thirty-eight operated cases, fourteen were completely cured and four only temporarily. The best way to open the skull is to make a pedunculated flap of soft parts and bone after Wagner (page 167). If, upon opening the skull, it is found impossible to remove the tumour, one should at least try to improve the patient's condition by a partial extirpation. Sometimes an operation performed in two stages is advisable (Sonnenburg).

III. **The Surgical Treatment of Epilepsy.**—As long as our knowledge of the nature and location of epilepsy remains as imperfect as it is to-day, the propriety of operative measures for its treatment must be

weighed in each individual case. Operations without definite plan have frequently been attempted, and have been injurious to brain surgery. Little that is trustworthy is known of the final results of trephining for epilepsy. According to Agnew's statistics, the successful results have been only temporary in character, and in the majority of cases the epilepsy returned, while really permanent cures are extremely rare. It should always be borne in mind that the operation itself, or rather the resulting cicatricial contraction and abnormal adhesions of the dura, may cause a return of the epilepsy. In other cases recurrences of an epilepsy are caused by an incomplete removal of the cause. We leave out of consideration here the reflex epilepsy due to a lesion of the nerves in the soft parts of the skull which, as we have already mentioned, has been temporarily or permanently cured by excision of a cicatrix in the skin.

Only those cases of epilepsy are susceptible of operative treatment which are caused by palpable and hence removable lesions of the cortex. This applies to those cases in which the spasms always begin in a certain group of muscles, then spread in a distinct and typical way along the same and opposite sides of the body and become general, and finally give place to temporary or more permanent one-sided paralyses in those groups of muscles which are the first to be affected by the spasms, so that the point of origin may be definitely located in the cortex (so-called Jacksonian epilepsy). In these cases of Jacksonian epilepsy the object of the operation is to free from its source of irritation or remove entirely that motor area which acts as an exciting centre for the spasmodic contractions of the muscles first affected. This form of epilepsy may be caused by various disturbances in the different parts of the motor zone of the cortex. After opening the skull, the further course of the operation will depend upon the abnormality that presents itself. Splinters or projecting portions of bone, cicatrices, tumours of the dura, etc., must be remedied, and, above all, the diseased cortical area should be removed. Horsley recommended a determination of the epileptogenic zone by means of faradization of the cortex, and then removal of the same. This proposal of Horsley's can easily lead to error if, for example, the cortical epilepsy is caused by a subcortical focus. Kümmell trephined at that portion of the skull which was especially tender on percussion ; a localized point of tenderness is said to exist in many epileptics. In order to differentiate true epilepsy from the hysterical forms, Charcot and Gilles de La Tourette recommended examination of the urine, as it is said that the attacks of true epilepsy are followed by a marked increase in the amount of urates and phosphates, while in the case of the hystero-epileptic attacks there is a dis-

tinct decrease. To prevent cicatricial contraction and abnormal adhesions at the site of operation, and herewith the danger of recurrence, Fraenkel recommends grafting epidermis on to the fresh wound in the brain, and closing the defect in the bone by means of a smooth aseptic celluloid plate.

Kocher, who is in favour of an operative treatment of traumatic epilepsy, thinks that epilepsy in general is in many cases dependent upon increased tension of the cerebro-spinal fluid with over-irritability of the brain; the attacks are, according to him, due to change in the amount of blood and cerebro-spinal fluid within the cranium. The epileptic onset acts, in the presence of abnormal irritability of the cortex, in the same way as a concussion of the brain, especially in the cases of Jacksonian epilepsy. In order to overcome the increased pressure of the cerebro-spinal fluid, Kocher has employed drainage of the ventricles of the brain for weeks and even months.

Among the other methods of operative treatment for epilepsy I should mention extirpation of the upper cervical ganglion (Alexander), and ligation of the vertebral artery (see § 90), also recommended by Alexander. Ligation of the vertebral artery by means of which the venous congestion in the medulla is thought to be overcome has not been very successful, but the results from ligation of both artery and vein, with division of the cervical sympathetic above the lower cervical ganglion, are better.

Horsley has also made that persistent, sharply localized form of cephalalgia which resists every other form of treatment an indication for trephining. This may be caused by atrophy of the cranial bones due to abnormal pressure, such as that from an epidural extravasation of blood, Pacchionian granulations, etc. I agree with Krönlein, Sahli, and others, who are distinctly opposed to this suggestion of Horsley's.

Macewen has operated on twenty-one cases in brain surgery, leaving out of account fresh injuries of the brain, with only three deaths. The cases consisted of cerebral abscesses, tumours of the dura and brain, gummata, cysts, blood clots, tuberculomata, and old depressions of the skull. Jacksonian epilepsy was observed among these cases several times. In single instances a permanent cure resulted.

Tellier has made an exhaustive study of the later effects of injuries of the skull and their treatment from fifty-four cases collected from literature and two observations of his own. The cerebral disturbances affect partly the motor and partly the sensory or psychic sphere. Among the most frequent causes that can be demonstrated are splinters of bone, depressed bone, exostoses, adhesions of the dura mater with the brain, remnants of old blood clots, abscesses, cicatrices following meningo-encephalitis, tumours (cysts, gliomata), etc. In the case of cerebral motor disturbances due to changes in a certain motor area, trephining, with removal of the exciting cause, fur-

nishes a comparatively favourable prognosis. In sensory and psychic disturbances surgical interference is usually not indicated except in the case of severe and distinctly localized cephalalgia. In disturbances of the mental sphere resulting from injuries of the skull, especially when cicatrices or fistulæ are present and other causes can be excluded (syphilis, heart lesions, heredity, etc.), Tellier recommends trephining, particularly if the cerebral symptoms are localized and a constant, circumscribed area of tenderness is present. In general paresis following injuries of the skull not much can be expected from operative interference. Trephining should likewise not be attempted in traumatic hysteria (Charcot). For the surgical treatment of epilepsy see page 148.

Puncture and Drainage of the Lateral Ventricles of the Brain.—In order to relieve pressure upon the brain in case of tubercular meningitis, hydrocephalus, brain tumours, and the like, Bergmann and Keen have tapped, and in some cases drained, the lateral ventricles. It is possible that in tubercular meningitis the removal of the exudate may bring about a degeneration of the tubercles, such as takes place after laparotomy for tubercular peritonitis. Bergmann operated as follows: He chiselled out a piece of bone just above and to the inner side of the frontal eminence and inserted a long, hollow needle from in front backward with a slight deviation downward and inward until cerebro-spinal fluid came out in a stream. After twenty cubic centimetres of the clear fluid had been removed the needle was withdrawn and the hole in the skull packed with iodoform gauze. After the operation there followed a temporary improvement, but on the third day renewed convulsions and Cheyne-Stokes breathing appeared, and death took place on the fourth day.

Keen proposes three routes for puncture of the ventricles—viz., from behind, from in front, and from the side. He recommends chiefly the last method, which he does as follows: He trephines at a point an inch and a quarter behind the external auditory meatus and an inch and a quarter above Reid's base-line drawn from the lower border of the orbit through the centre of the meatus (see Fig. 81, page 171). The needle is inserted in the direction of an imaginary point, two and a half inches vertically above the external auditory meatus of the other side. This line of puncture traverses the second temporal convolution and enters the normal ventricle at the beginning or in the course of the descending cornu, which is situated about two to two and a half inches from the surface. These measurements apply to adults. In performing puncture, one must always avoid (1) the motor zone; (2) the neighbourhood of the fissure of Sylvius; and (3) the known centres of special sense. If the dura is intact, Keen uses a hollow needle for puncture; otherwise he recommends a grooved director because it injures fewer vessels. The after-treatment may be difficult in case the cerebro-spinal fluid flows out in great amounts. Keen has successfully performed the above-described puncture of the lateral ventricles on both sides, and drained and irrigated the ventricles from one side to the other with good results. The patient was cured. I tapped the lateral ventricles in two cases of brain tumour with only temporary success in both cases. In one of the patients, who had become completely blind, the puncture brought about a temporary improvement in his vision.

Craniectomy for Microcephalus and Idiocy.—Lannelongue has performed craniectomy twenty-five times, in microcephalic persons and those with retarded mental development, by the formation of a gap in the bone like a suture which is meant to compensate for the premature ossification of the normal sutures and the smallness of the fontanelles, and to allow a growth of the brain to take place. Lannelongue operates according to two methods—i. e., he does either a linear craniectomy or the flap method. By the former method he makes an incision on one or both sides parallel to the longitudinal fissure and about a finger's breadth from it, and removes a strip of bone from nine to twelve centimetres in length and one half to three quarters of a centimetre in breadth, reaching from the frontal to the occipital suture. A portion of bone has also been resected from the frontal or from the frontal and parietal bones. Postemsky cuts out triangular or quadrangular plates of bone so that they form a movable vault. Gersuny divides the cranium into two portions by a circular cut, just as in performing an autopsy. The upper portion of the cranium then overtops the brain like a bony cap. I did the operation by dividing the skin and periosteum in a straight line, and then, after making with a trephine a hole in the parietal bone from one half to three fourths of a centimetre in diameter in a straight line from in front backward, removed with narrow rongeur forceps a strip of bone nine to twelve centimetres by half a centimetre in length. The wound in the skin was then closed by sutures with the exception of the posterior lower angle. Union followed without any reaction. The dura should not be injured, but if it is, it should be sutured at once. Lannelongue and others have carried the incision forward beyond the coronal suture as far as Broca's speech centre—i. e., two to three centimetres above the eyebrows. Posteriorly the incision can be continued on the occipital bone between the lateral sinus and the occipito-parietal suture. Lannelongue has also performed a transverse craniectomy on the frontal bone, and then separated the longitudinal sinus from it.

Instead of making a linear incision, one may dissect back the skin so as to form a long-oval, omega-shaped, or right-angled flap, and then resect the bone as above. The flap method has the advantage that the opening in the skin does not correspond with the cleft in the bone, so that the latter is afterward well covered with soft parts. I operated in this way in my last case.

Lannelongue lost, among twenty-five cases, only one from sepsis. The youngest child was eight months old and the oldest twelve years. In the majority of cases the intelligence as well as the gait of the patients improved. Rabow, Roux, Horsley, Starr, Morrison, Keen, the author, and others have also performed the operation successfully. Time is necessary before one can tell whether permanent favourable results have really been achieved by the operation, but I doubt it.

I consider with Marchand, Bourneville, and others that craniectomy for microcephalus is in the majority of cases an unjustifiable operation, because we almost always have to deal with a congenital malformation of the brain which is not influenced by the formation of defects in the skull. The growth of the brain in microcephalus is not prevented by the cranial bones or synostosis of the cranial sutures, but the brain remains too small because there is too little brain matter present.

It is only in exceptional cases of microcephalus with premature closure of the cranial sutures and fontanelles that craniectomy finds its justification.

For the location of the most important fissures and convolutions of the cortex and the cortical centres in their relation to the cranial bones see Figs. 79 and 80, pages 169, 170.

§ 21. **Hydrocephalus.**—By hydrocephalus is meant an accumulation of water within the cranial cavity. A distinction is made between hydrocephalus meningeus or externus—i. e., a collection of fluid (hydrops) in the subdural space, between the dura and brain, in the soft membranes of the brain—and hydrocephalus ventriculorum or internus—i. e., a collection of fluid within the ventricles of the brain.

1. Hydrocephalus meningeus or externus is very rare, and is either congenital or acquired. Congenital hydrocephalus externus occurs either alone, in conjunction with deficient development of the brain, which allows fluid to collect between the brain and the skull, or hydrops ventriculorum is present at the same time. Children of this sort usually die a few weeks or months after birth. Acquired hydrocephalus externus is observed mainly in children and adults, with atrophy of the brain from marasmus following serious illnesses, etc. Occasionally acquired hydrocephalus is circumscribed or encapsulated in a certain place, after chronic inflammation of the dura, for example. These cystic formations are also known under the name of hygroma of the dura.

2. Hydrocephalus ventriculorum, or true hydrocephalus (see Fig. 68), is, as a rule, congenital, less often acquired, and in the latter case usually appears in the first few years of life. We shall leave out of consideration here that form of hydrocephalus ventriculorum which may appear at any age as the result of various diseases of the brain and its membranes.


Fig. 68.—Hydrocephalus.

Congenital hydrocephalus is in the main a malformation of the brain. The latter is developed from membranous vesicles, the walls of which gradually become converted into brain matter, so that the inner spaces, which are filled with fluid, contract more and more and become the ventricles. The cerebral hemispheres develop from one vesicle, which becomes divided by an infolding in the median line. If now the development of the brain is impeded for any reason, the fluid that is present in the anterior vesicles does not diminish in amount. In other cases the increase in the fluid is primary and, as a result of this, the normal formation of brain matter is retarded. If a certain amount of fluid persists permanently, the brain matter then atrophies more and more from the pressure of the fluid and the latter increases correspondingly in amount. In addition to this, the still soft, partly membranous cranial wall gradually yields. Frequently the central canal of the spinal cord also becomes dilated, so that hydrorrhachis results (see Diseases of the Spinal Cord).

The special causes underlying congenital hydrocephalus are only imperfectly known, but are in the main probably inflammatory in character. Syphilis and alcoholism on the part of the parents are very frequently thought to be to blame (Oedmanson, Bär, and others).

If the hydrops increases rapidly in an early fœtal period the cerebral vesicles may burst and an *acephalus* results—i. e., at the birth of the fœtus the base of the brain alone is found with the corresponding portion of the skull. Acephalia may also result in case the epiblast from which the medullary canal is developed does not become closed in the neighbourhood of the cerebral vesicles.

Acquired hydrocephalus ventriculorum results from an increase in the fluid within the ventricles, which occurs usually in the first years of life from inflammatory and hyperæmic processes in the meninges, choroid plexus, and ependyma, and in rare cases from closure of the vena magna Galeni, and the straight sinus due, for example, to an exudate or a tumour. Acquired hydrocephalus is confined, as a rule, to rhachitic children.

The size of a hydrocephalic brain is very variable. The total amount of the fluid may reach 2,000 to 4,000 cubic centimetres, and in one case Cruikshank is said to have found 15·5 kilogrammes. Most of the fluid is found in the lateral ventricles, and can reach such an amount that the hemispheres are converted into large sacs, while the brain matter either disappears entirely or is present only in thin layers. The cerebellum and cranial nerves usually remain unchanged. The skull increases correspondingly in size, the bones becoming further separated from one another by membranous interspaces (see Fig. 69) and are thin and translucent. The disproportion between the distended skull and the small face is very noticeable (see Figs. 68 and 69). The eyes are usually pushed forward and downward, because the roof of the orbit is pressed downward. The eyebrows are displaced upward.

Fig. 69.—Cranial capsule in hydrocephalus (Pathological Institute at Leipsic).

In congenital hydrocephalus the fœtuses often die before birth, or soon after. If the child continues to live, there develop, besides the above-described changes in the skull, increasing functional disturbances of the brain. The intellectual development is backward, and the child learns to talk late and imperfectly or not at all. The development of the rest of the body suffers because the children, on account of the weight of the head, prefer to lie down.

Acquired hydrocephalus develops sometimes quickly and sometimes slowly, and often with corresponding cerebral manifestations (headache, impairment of the intellect, epileptiform attacks).

The prognosis of hydrocephalus is bad, and death usually occurs from an increase in the amount of fluid or from intercurrent diseases. Sometimes children live for several years, even with a very marked hydrocephalus, if it remains stationary or diminishes.

Generally speaking, it is rare for individuals with hydrocephalus to live to be thirty or forty years old. In exceptional cases, even when the hydrocephalus is very marked, recovery may result from gradual absorption or from spontaneous rupture through the skull (Rokitansky and Baron). In mild cases of hydrocephalus recovery is more frequent, especially in rhachitic hydrocephalus after the rhachitis has disappeared.

The diagnosis of hydrocephalus can be made with certainty only when the expansion of the skull can be detected at the fontanelles and cranial sutures. As regards the differential diagnosis between hydrocephalus externus and internus, Hewett lays stress on the fact that the above-mentioned characteristic position of the eyes and displacement of the roof of the orbit occurs only in hydrocephalus ventriculorum, but that absence of this symptom does not exclude the latter.

The treatment of hydrocephalus is, in the majority of cases, completely powerless.

In mild cases of acquired hydrocephalus, cathartics, diuretics, and baths are to be recommended, and especially good food, air, etc. In case of rhachitis, this should be treated first of all (see Principles of Surgery, § 108).

In severe cases aseptic puncture followed by compression has been recommended. It is often difficult to decide whether one should resort to puncture and when it should be performed. It has but seldom resulted in a cure. Puncture is most applicable to those cases in which the hydrocephalus is increasing rapidly in amount and the nervous disturbances are becoming more marked, as well as in hydrocephalus which is congenital or appears soon after birth, where the skull is soft and can still be diminished in size by compression.

Aseptic puncture is performed with a sterilized trocar or aspirating needle of small calibre through the membranous portion of the skull close to the sagittal suture, care being taken to avoid the longitudinal sinus. The trocar or needle should be inserted to a depth of two to five centimetres until it enters the ventricle. The field of operation must first be disinfected by scrubbing it with soap, shaving the hair, and rubbing the skin with ether and 1-to-1,000 bichloride. According to the degree of the hydrocephalus, fifty to two hundred grammes should be drawn off. If necessary, the tapping should be repeated. Aspiration and even injection of the tincture of iodine have been combined with puncture without producing any evil effects. After the operation an antiseptic protective dressing should be applied. In order that decomposition may not take place, the dressings should be changed very soon if much fluid continues to come out through the puncture opening which has been left open. (For a description of puncture and drainage of the lateral ventricles which have also been performed for hydro-

cephalus, see § 20.) The good results are usually only temporary, but permanent improvement of the general health, diminution in the number of convulsions, restoration of the power of vision, etc., have been brought about.

Spinal puncture of the subdural space in the lumbar region is also advisable, in order to ameliorate the patient's condition.

§ 22. **Herniæ Cerebri, or Cephaloceles.**—By these terms tumours are meant which are usually congenital and situated beneath the scalp. They leave the cranial cavity through a gap in the bone, and consist of portions of the contents of the skull (cerebral membranes with or without brain matter). Congenital herniæ of the brain are not true herniæ, but malformations or ectopiæ of the contents of the skull which have developed outside the cranial cavity. Acquired herniæ, on the other hand, result usually from prolapses of the brain, which are due to the presence of defects in the bone following injury or inflammatory processes, and have been described in § 18.

I. Congenital hernia cerebri or cephalocele is most commonly found in the occipital region and at the root of the nose, less often in the anterior inferior region of the parietal bone and the vicinity of the sagittal suture, and in exceptional cases at the base of the skull. By the term cephalocele we include all hernial tumours occurring on the head.

Fig. 70.—Hernia cerebri occipitalis in a child five months of age (Lücke).

According to their contents we differentiate the following varieties of cephalocele: (1) Meningocele—i. e., a protrusion of the membranes of the brain filled with a serous fluid; (2) Encephalocele, which contains at the same time brain matter; and (3) Hydro-encephalocele, in which the brain matter lying in the hernial sac is distended by a collection of serous fluid in its interior, or, in other words, by an enlarged ventricle filled with fluid. In rare cases, as in one reported by Billroth (Fig. 73), these hydro-encephaloceles may resemble meningoceles, in which, however, the outer sac communicates with the ventricles by a small opening.

The most common cephaloceles are those of the occiput (see Figs. 70 and 71), in which locality they emerge from the skull either above the occipital protuberance and tentorium cerebelli, or below this point, and corresponding to this difference in situation are known as the superior and the inferior occipital hernia cerebri. In the case of the inferior occipital hernia the gap in the bone is sometimes not separate from the foramen magnum, and forms an expansion of the latter.

The cephaloceles of the anterior portion of the skull (sincipital cephaloceles) are found in the region of the root of the nose and spread from here toward the forehead, orbits, or nasal cavity (naso-frontal, naso-orbital, and naso-ethmoidal cephaloceles).

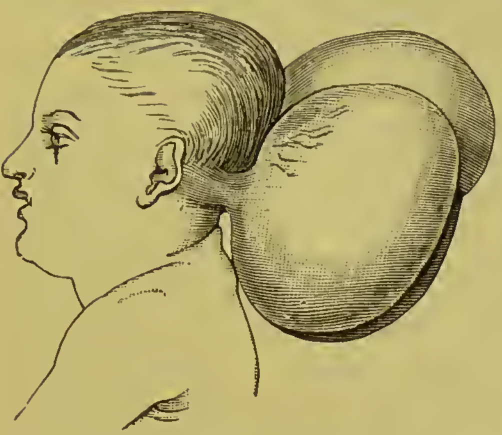


Fig. 71.—Hernia occipitalis inferior divided by a furrow (Büttner).

Fig. 72.—Hernia cerebri naso-orbitalis (Niemeyer)

The occipital and sincipital cephaloceles occur, according to Larger, with about the same frequency.

The lateral cephaloceles in the region of the parietal bone (Fig. 73) and the sagittal cephaloceles in the neighbourhood of the sagittal suture and the large fontanelle are much rarer. Dermoid cysts also occur in these regions, and when lying in a gap in the bone should not be mistaken for a cerebral hernia.

Fig. 73.—Cephalocele (hydrencephalocele) of the vault of the skull; *A*, before puncture; *B*, after puncture (Billroth).

The cephaloceles of the base of the skull are very rare, and usually pass through a gap in the bone between the body of the sphenoid and the ethmoid into the nasal and pharyngeal cavities (spheno-pharyngeal cephalocele), or through a fissure of the palate out through the mouth (palatine cephalocele,

see Fig. 74), or they emerge through the sphenoidal fissure into the orbit (spheno-orbital cephalocele), or, finally, through the spheno-maxillary fissure into the spheno-maxillary fossa (spheno-maxillary cephalocele).

Herniæ of the brain vary a great deal in size, as may be seen from the illustrations. In some cases they are hardly noticeable, and in others the size of a child's head. They are either more or less pedunculated or sessile. The communication with the cranial cavity is sometimes very small. Their surface is in some cases smooth, and in others furrowed and marked off into separate lobes. The amount of fluid they contain also varies, so that they are sometimes loose and sometimes tense. A distinct pulsation is often present. The more fluid a cephalocele contains, the more translucent it is. The outer coverings are often much thinned, excoriated, or covered with cicatrices. The hernial sac consists of the protruding dura which is either adherent to the external soft parts, or, what is less frequent, separated from the latter by an accumulation of serum or lipoma formation.

Fig. 74.—Hydrencephalocele palatina in an infant emerging through a wide opening between the sphenoid and ethmoid bones (Virchow).

Herniæ of the brain can usually be diminished in size by pressure and less frequently reduced altogether. Reduction is easiest in the case of meningoceles which contain fluid. The pressure made during attempts at reduction not infrequently causes cerebral manifestations, and firm pressure sometimes gives rise to vomiting, slowing of the pulse, unconsciousness, and convulsions.

As regards the origin of congenital herniæ of the brain there are various hypotheses. They are looked upon as malformations due to irregularities in the division, during fœtal life, of the brain into its separate parts so that portions of the primitive cerebral vesicles remain lying outside the mesodermic covering. According to Paul Berger and others, many encephaloceles are really neoplasms which began their development at a very early embryonic period, and such cases might be designated as "encephalomata." In two cases of encephalocele Berger found that the nervous elements of the extirpated tumours belonged to the cerebrum as well as the cerebellum, and that these lay next one another without any sharp boundary. This fact is in accordance with the view that encephaloceles are mainly due to an abnormality in the development of the primitive cerebral vesicle. Other important etiological factors are defects in the skull, abnormal adhesions, and outward traction on the contents of the skull from various causes, such as adherent amniotic strands, etc. Heineke has discussed the etiology of congenital cephaloceles at great length in the Deutsche Chirurgie (Lief 31, p. 232), and the reader is referred to this. Acquired herniæ of the brain occur after compound comminuted fractures which are circumscribed, and especially after gunshot fractures and other defects in the skull (see § 18, Prolapse of the Brain). Acquired herniæ of the brain and its membranes are not to be confounded with those soft, sometimes pulsating tumours, which occasionally develop after subcutaneous fractures of the skull in consequence of the escape of cerebro-spinal fluid (see page 48, Fractures of the Skull).

The clinical behaviour of congenital cephaloceles varies with the variety and the contents of the hernia.

In regard to meningoceles or herniæ of the membranes of the brain, the meningocele occipitalis inferior is the most common, then the superior, while the one in the anterior portion of the skull is rarer. In the milder cases the brain is normally or nearly normally developed, but malformations of the brain are usually present, especially hydrocephalus and microcephalus. The tumour formed by the hernia rarely pulsates, has a smooth surface, usually increases uniformly in size when the child cries, and can be made smaller or emptied entirely by pressure. If in the attempt to reduce the tumour a strong and rapidly increased pressure is applied, the above-mentioned cerebral symptoms immediately make their appearance. Children with congenital cephaloceles often die during delivery or soon after. In other cases the tumour increases more or less rapidly in size and can finally burst. Death may then take place from suppurative meningitis. Sometimes meningoceles remain stationary in size, and the children may live for some time. Heineke mentions cases of meningocele in patients from twelve to seventeen years of age. Spontaneous cures rarely take place after the birth of the child and only to a limited extent, but occur more commonly during intra-uterine life from closure of the opening in the skull. The serous cysts of the scalp (see page 30) are in part encapsulated meningoceles that have lost their communication with the interior of the skull. If malformations of the brain accompany a meningocele, corresponding cerebral disturbances are of course present (paralyses, contractures, convulsions, idiocy, etc.).

Encephaloceles or herniæ which contain brain matter are much more common than meningoceles. The portion of brain that lies outside the cranial cavity is usually connected by a pedicle with the rest of the brain. The portion of brain lying within the hernial sac is sometimes solid and sometimes hollow and distended with fluid, in which case the cavity communicates with a ventricle (hydro-encephalocele, see page 160).

Simple encephaloceles are mainly found in the frontal, less frequently in the occipital region, and usually form small elastic tumours with a broad base. If at the same time there is a considerable collection of serous fluid in the dural sac—i. e., a meningocele—the tumour is more transparent and fluctuates. A hernia cerebri pulsates distinctly and becomes larger when the child cries and coughs. In the more severe cases of congenital ectopia cerebri the children are stillborn or die soon after birth. In dead fœtuses the whole brain, or at least the greater part of it, is occasionally found in a sac joined to the hemi-

cephalic or microcephalic skull. Sometimes the tumour remains stationary in size after birth, and the children become physically perfectly well developed. The cerebral disturbances depend, of course, upon the size of the tumour, or, in other words, the degree of the malformation of the brain. According to Heineke, children with hernia cerebri occipitalis rarely live beyond the age of puberty, and are, as a rule, idiotic, while children with an encephalocele of the frontal region are more likely to live longer, and may be of nearly normal intelligence.

In encephaloceles, also, a rapid enlargement of the tumour may take place from an increase in the amount of fluid within the hernial sac. Rupture of the tumour may then give rise to meningitis and encephalitis. Occasionally encephaloceles are combined with tumours, such as lipomata, fibro-lipomata, cavernomata, etc.

Hydro-encephaloceles are usually of a very large size, and are most frequently found in the upper occipital region, in which case they, as a rule, contain the distended posterior cornua of the lateral ventricles. They are less frequent in the lower occipital region, and the hernial sac then usually contains the cerebellum with the distended fourth ventricle and sometimes portions of the posterior lobes of the cerebrum and cerebellum. Hydro-encephaloceles in the frontal region and at the base of the skull, containing the distended anterior cornua of the lateral ventricles, are rare (see Fig. 74). The protruding sac is sometimes partially or entirely devoid of brain matter, as, for example, in Billroth's case illustrated in Fig. 73. The amount of fluid varies considerably, amounting on an average to from four hundred to eight hundred grammes. The portion of brain lying within the cranial cavity is usually the seat of various malformations and signs of arrested development (hydrocephalus and microcephalus).

Hydro-encephaloceles of the base of the skull not infrequently show a great tendency to progressive enlargement. Children with hydro-encephalocele die sometimes *in utero*, sometimes during birth, or within a few days after birth, and only in exceptional cases live any length of time. Heineke mentions a case observed by Eager where the child lived to be two years and five months old. In cases of this sort which live for some time death finally takes place, as a rule, from progressive enlargement of the hernia with convulsions, or from rupture of the tumour.

For the diagnosis as to which kind of hernia is present it should be remembered that meningoceles and hydro-encephaloceles occur most frequently in the occipital region, and the true herniæ of the brain or encephaloceles in the frontal region. Encephaloceles are characterized by pulsation,

which is absent in meningoceles and usually in hydro-encephaloceles. Meningoceles fluctuate distinctly, can be made smaller by pressure or completely reduced, and are more translucent. If a very large hernial tumour is found in the occipital region, one can usually make the diagnosis of hydro-encephalocele.

It would be very desirable, as far as the treatment is concerned, to be able to determine exactly the portion of brain involved, but that is very difficult or even impossible. Horsley was able in one case to make the correct diagnosis with the aid of a faradic current.

True meningoceles should not be confused with the false—i. e., circumscribed cysts situated over defects in the skull—the former having no communication with the interior of the skull (see page 30).

Treatment of Cephaloceles.—Meningoceles are especially adapted to a surgical treatment by aseptic puncture and compression. If a cure of the meningocele is not obtained in this way, it would be a good plan to incise the sac and extirpate it as completely as possible under antiseptic precautions, or to tie off the sac with catgut at the point where it leaves the skull and then remove it. Puncture followed by the injection of tincture of iodine or absolute alcohol has also been tried. If it is impossible to cure a meningocele by radical measures, one should at least arrest the growth of the tumour by compression and prevent rupture by tapping.

Encephaloceles were at one time regarded as a *noli me tangere.* At the present time most surgeons take the view that in suitable cases a radical operation should be performed. One has to decide in each individual case whether one should operate or not. Those cases are not suitable for operative treatment in which the amount of prolapsed brain is so great that the life or the subsequent cerebral functions of the individual in question are endangered. All those cases are likewise to be regarded as inoperable which are complicated by other serious malformations, such as large gaps in the skull, microcephalus, etc. The radical operation consists, in suitable cases, in opening widely the hernial sac by cutting, for example, two skin-flaps, exposing the pedicle, transfixing it and applying a double ligature of catgut, cutting away the tumour or portion of brain in case it can not be reduced, and covering the defect by suturing together the two skin-flaps. De Ruyter recommends that the operation be begun at the lower pole of the cyst, in order to determine exactly the nature of the tumour and its relations to the cranial cavity. After completion of the operation the remnant of the cyst should be carefully sutured together, in order to close the cranial cavity and prevent the escape of cerebro-spinal fluid which otherwise can often not be stopped. Hildebrand, Alberti, Perier, Bergmann, Mittendorf, and others have performed the radical

operation for encephalocele, and some have had good results. De Ruyter's reports from Bergmann's clinic show, however, that the results of the operation are not encouraging. The small encephaloceles in the frontal and occipital regions are most suitable for extirpation, with removal, it may be, of the prolapsed portion of brain. Removal of brain matter from this region causes, as a rule, no functional disturbances. In the case of occipital encephaloceles one should, of course, bear in mind the visual centre, which must be left intact (see Fig. 57). In all cases in which the prolapsed portion of brain can be replaced without causing severe cerebral symptoms this should be done, and the sac extirpated or cut off after ligating the pedicle. It is sometimes a good plan to remove the fluid in the hernial sac by puncture, and to prevent its reaccumulation, as far as possible, by means of a dressing that exerts pressure. Encephaloceles are not infrequently complicated by tumours, such as lipomata, fibro-lipomata, cavernomata, etc.

In order to protect a hernia of the brain from external violence, one may make use of trusslike appliances in case these do not cause cerebral symptoms.

In hydro-encephaloceles an effective surgical treatment is usually impossible, and the children often die very soon in consequence of an increase in the size of the tumour.

II. **Acquired Hernia Cerebri.**—This condition occurs mainly in consequence of defects in the skull which have resulted from traumatisms or pathological processes such as syphilitic or tubercular caries. It is really a prolapse of the brain through the gap in the bone, the dura either being divided or weakened by inflammatory changes. For a more detailed description of prolapse of the brain the reader is referred to § 18.

The possibility of the development of a meningocele in later life is doubted by Heineke. Havars and Lawson, on the other hand, claim that they have seen cases of this sort. As we have already mentioned, true meningoceles must not be confused with the false variety—i. e., circumscribed cysts situated over congenital or acquired defects and fissures of the skull. These serous cysts of the scalp may result, for example, from the encapsulation of cerebro-spinal fluid after a fracture of the skull. The serous cysts of the scalp which result from meningoceles that have ceased to communicate with the interior of the skull are probably always congenital. Dermoid cysts situated in a gap in the bones, vascular pulsating sarcomata, and the like, must not be mistaken for a hernia cerebri (see pages 29 and 36).

As regards the treatment of acquired hernia cerebri the reader is

referred to the rules given on page 161 for congenital hernia cerebri, and to § 18, Treatment of Prolapse of the Brain.

§ 23. **Trephining and Temporary (Osteoplastic) Resection of the Skull.**—By trephining we mean opening the cranial cavity by the removal of a portion of bone of any desired shape and size.

History of Trephining.—Trephining is a very old operation. In the writings of Hippocrates, particularly the chapter on wounds of the head, the operation of trephining is described as being known for a long time, and appears to have been very well developed. Even in those days the present trephine crown was in use. I have shown that in the stone age also trephining was successfully employed on the living person and was widely known (Prunières, Broca). Moreover, those people who still live in the stone age—such as, for example, the South Sea islanders, the natives of Tahiti and the Pomotu islands—still trephine with their stone knives for certain diseases and injuries of the brain. The bone is scraped through by means of flint or glass. Whoever is interested in this prehistoric surgery is referred to my treatise on the subject (Ueber praehistorische Chirurgie, in Langenbeck's Archiv für klinische Chirurgie, Bd. xxviii).

Trephining has, since the age of Hippocrates, undergone several revolutions up to the present time. At one time it was made use of too freely. Paré, in particular, recommended the operation very warmly, and gave numerous indications. Mehée de la Touche went so far as to trephine one patient fifty-four times within two months. The trephine was, in fact, used to search for the probable location of the injury or disease of the brain of which no one had sufficient anatomical and physiological knowledge. Désault in the last century, and then Sir Astley Cooper in this, were the first to limit very considerably the indications for trephining. After this a time followed when the operation was almost completely abandoned by some surgeons, especially Stromeyer.

Modern surgery has wisely revived the operation, but in the light of our more exact knowledge of the anatomy and physiology of the brain its indications are very much limited. With the aid of antisepsis the operation can at present accomplish much better and surer results than formerly. According to Blume's careful statistics, among 709 fractures of the skull which underwent trephining, 357 recovered and 352 died, being a mortality of 49·65 per cent. These statistics do not refer to the aseptic operation, which could be easily proved to be entirely devoid of danger. Bergmann is right in drawing attention to the fact that in the above cases also it was probably not the operation itself, but solely the injury for which trephining was performed, that determined the fatal result. Walsham estimates the mortality of the operation when performed antiseptically at from 10·6 to 14·4 per cent.

At the present time, in place of the typical operation of trephining, temporary (osteoplastic) resection of the cranial bones is frequently substituted.

Among recent works on trephining, Galley's book, which received a prize from the Belgian Academy, should be spoken of. It is entitled La Trépanation du crâne; histoire, technique opératoire, indications et contra-indications; résultats. Bruxelles, 1893.

The most important indications for opening the cranial cavity are as follows: Fractures of the skull, especially comminuted fractures, with injury of the brain or focal symptoms, intracranial foreign bodies, hæmorrhage from the middle meningeal artery, the different causes of compression, necrosis of the cranial bones, brain abscesses and other localized brain diseases, circumscribed tumours, caries, tumours of the brain and its membranes, but only in a limited number of cases, and finally epilepsy. The surgical treatment of insanity still lacks, in the present state of our knowledge, a scientific basis. For further details I refer to § 4, § 11, and §§ 14–19, and especially § 20 (Surgical Treatment of Diseases of the Brain).

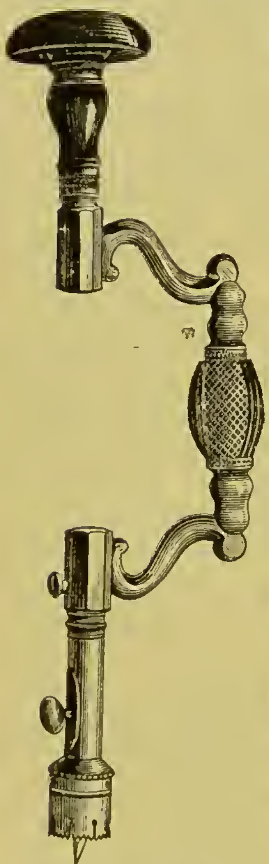


Fig. 75.—"Brace-trephine."

At the present time the cranial cavity is opened in several different ways:

1. A button of bone may be removed with a trephine.

2. Pieces of bone may be sawn out of the skull by means of specially constructed saws—such, for example, as a circular saw which is attached to a dentist's rotating machine.

3. Chiselling away and cutting out fragments of the skull.

4. Clipping off projecting edges of bone and pulling out or lifting up partially or entirely loosened fragments after a fracture.

Before opening the skull the field of operation should be thoroughly shaved and disinfected in the usual way. Comatose patients should, of course, not be anæsthetized.

The best plan is to shave the entire scalp. If there is a wound of the soft parts, it should, when necessary, be sufficiently enlarged. If there is no wound present, the soft parts should be divided by a cruciform, or, better, a curved-flap incision (see Fig. 61), down to the bone, so that the flap includes the periosteum. The periosteum is separated from the bone by means of a periosteal elevator.

The removal of a button of bone, or trephining, in the narrow sense, is done either with a hand-trephine (Fig. 76) or "brace-trephine" (Fig. 75). In the centre of the crown of the trephine there is an adjustable piece, the so-called centre-pin, which is pushed forward several millimetres beyond the plane of the teeth of the trephine and secured in place. This centre-pin is then inserted into a small hole

previously made with a drill or the so-called perforating trephine, and the bone is then sawn through with the hand- or brace-trephine. The hand-trephine is turned on its long axis by means of pronating and supinating movements of the hand, while the brace-trephine, on the other hand, is steadied with the left hand at the upper knob-shaped end, seized with the right at its middle portion, and then made to revolve in the same way. When a sufficiently deep groove has been made in the external table of the skull the centre-pin is withdrawn in order that it may not be forced into the brain. A short bone-screw (*tire-fond*) may then be bored into the hole made by the centre-pin in order to remove the piece of bone that has been sawed out. In sawing, one must go through the whole thickness of the bone symmetrically. The instrument is removed frequently in order to clean out the particles of bone and test the depth of the groove with a probe. The deeper one gets into the bone with the crown of the trephine, the more slowly and carefully one should saw in order not to break suddenly through into the cranial cavity and injure the brain. When the inner table has been reached, one usually feels a slight cracking noise. In order to prevent injury of the brain by continuing to saw, the crown of the trephine is provided with an adjustable metallic cover (*abaptista*). The trephine invented by Mooy in Amsterdam is very serviceable in this particular. This instrument is so constructed that the button of bone which has been sawn out is immediately drawn up into the cavity of the crown by the action of a spring, and this shows the surgeon that the operation has been completed. After the button of bone has been taken out, the sharp projections on the inner table are usually removed with a probe-pointed knife. If the opening in the skull is too small for the case in hand, it may be enlarged by means of rongeur forceps or a chisel.

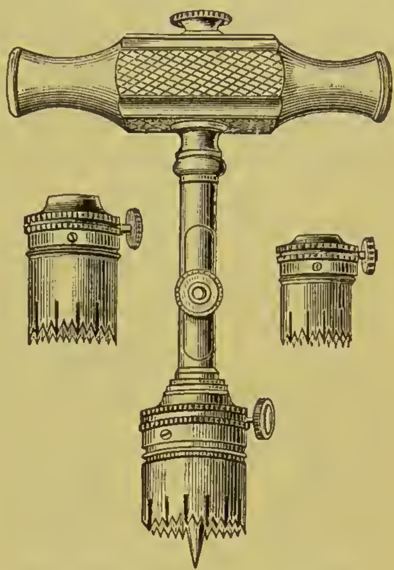


FIG. 76.—Trephine with three crowns of different sizes.

As regards the after-treatment, the following should be noted: If the operation has been performed for intracranial suppuration, the wound should be left open. In other cases, such as the extraction of splinters of bone, foreign bodies, etc., the wound should be drained and sutured, or lightly packed at first (without pressure), and then closed by secondary sutures, from one to four days later. In case the

brain has suffered laceration, Bergmann and Wölfler have advised that the wound be gently irrigated or sponged dry with 1-to-2,000 bichloride, sprinkled with a solution of iodoform in ether, and covered with sterilized iodoform powder, over which iodoform gauze and sterile gauze are applied. After twenty-four to forty-eight hours the wound is approximated by sutures.

The defect in the bone usually persists and becomes covered over with a membranous tissue that does not ossify. Such patients are therefore obliged to wear permanently a protective plate made out of metal or gutta-percha. Replacement of the button that has been removed is, generally speaking, not advisable, but it is preferable to transplant small pieces of cartilage from young animals or children. Macewen and others succeeded in making a bony closure of the trephine opening by dividing the button that had been removed into small pieces and transplanting them between the dura and the flap of soft parts which was covered with periosteum, leaving intermediate spaces for the escape of secretions.

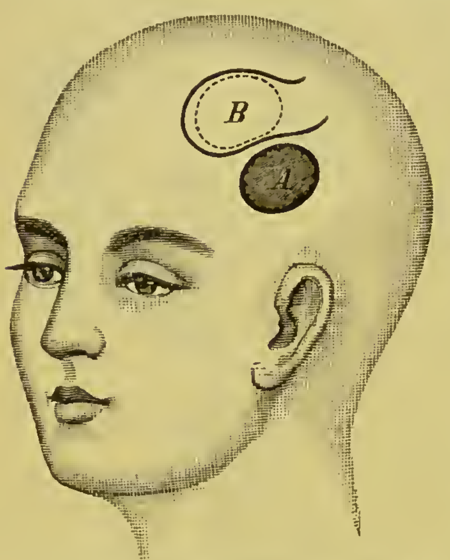


Fig. 77.—Closure of defects in the skull. *A*, defect; *B*, osteoplastic flap.

Keen succeeded in healing the button in place by keeping it wrapped up in warm aseptic compresses after its removal. If it was not kept warm it did not heal in place. Senn, Kümmell, and others recommend closing the defect in the bone by means of decalcified bone-plates. The decalcified bone becomes replaced in a comparatively short time by normal bony tissue. Another good plan is to close defects in the skull by means of a pedunculated flap of skin, periosteum, and bone taken from the immediate neighbourhood (König, Müller). The flap is made to include only the external table and a part of the diploë (see Fig. 77). In this way defects of a considerable size can be successively covered over (Schönborn). Eiselsberg and Hinterstoisser closed, in three cases, a bone defect of the skull by means of a celluloid plate two millimetres in thickness. The plate was cut out in such a way that it could be fitted into the defect only by exerting considerable pressure. The wound in the skin over the plate healed by primary union.

Occasionally defects are closed by a spontaneous growth of bone.

In place of the trephine, the chisel and mallet have been used a good deal of late in opening the skull. For this purpose the ordinary

sculptor's chisel, sharpened on one side and having a thick handle, is used, and an ordinary wooden mallet. The chisel is applied obliquely and a sufficiently large, flat-sided opening is slowly and cautiously made by means of short strokes of the mallet. All unnecessary concussion of the skull must be avoided. If the chiselling is done in the right way, fissures, necrosis, concussion of the brain, gliding off of the chisel, etc., can easily be avoided. Of late, however, many surgeons have given up the use of the chisel and mallet and returned to the trephine. Navratil observed a case in which the inner table was fissured in consequence of chiselling. Salzer believes that in one case of his an abscess of the brain ruptured in consequence of the concnssion caused by chiselling. He recommends the brace-trephine or a circular saw which is connected with a dentist's boring machine.

Opening the cranial cavity is often a very simple operation when one can remove completely or incompletely separated splinters of bone with bone-cutting or rongeur forceps and cut off projecting edges of bone with the same instruments. Depressed edges of bone can be raised by means of a periosteal elevator inserted underneath.

The removal of pieces of bone by means of specially constructed saws, such as Heine's osteotome or Hey's bridge-saw, is scarcely known at present. The instruments are too expensive and also difficult to manipulate. The use of the circular saw is, however, to be recommended, which can be connected with a dentist's boring machine.

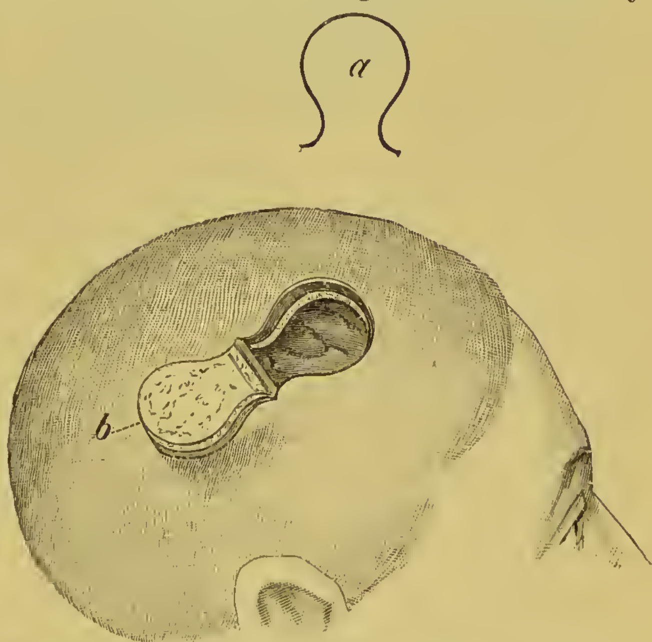


FIG. 78.—Osteoplastic resection of the skull. *a*, shape of the cutaneous incision; *b*, osteoplastic flap reflected.

Temporary or osteoplastic resection of the skull has of late been warmly recommended in intracranial operations as a substitute for trephining (Wagner, Wolff, Müller, König, Schönborn). Wagner proposed dividing the scalp by means of a Ω-shaped incision down to the periosteum. The skin is then retracted, the periosteum divided, and the bone chiselled through. The bone may be divided in the following way: A semicircular groove is first made in the bone with a narrow chisel,

and it is then chiselled completely through by means of heavy but narrow chisels, which are placed obliquely against the bone. After the bone has been divided on all sides, the bridge of bone still remaining beneath the bridge of soft parts is cut through transversely from both sides. The skin over both limbs of the omega is left to form a nourishing bridge and the bone beneath it is chiselled through subcutaneously. Finally, the flap, consisting of skin, periosteum, and bone, is reflected (Fig. 78 *b*), and at the completion of the operation, or during the after-treatment, it is sutured back again into place. It is best to leave the lower angle of the wound open. In Billroth's clinic the bone is divided, not with a chisel, but with the saw described by Salzer, which is a very good procedure.

It is likewise a good plan to follow the suggestion made by Müller and König, and make a flap consisting only of skin, periosteum, external table, and a portion of the diploë. After this flap has been reflected the remaining thickness of the skull is chiselled through. This plan, which is also suitable for covering over defects in the skull (see Fig. 77), is preferred by many to Wagner's method first described. König uses the latter method only for closing small defects.

For a description of craniectomy for microcephalia, see page 152.

For the treatment of prolapse of the brain after trephining, see § 18.

Trephining for intracranial hæmorrhage from the middle meningeal artery is described on page 112.

In Figs. 79 and 80 I have represented in a schematic way those cortical centres of which we have certain knowledge, and the most important sulci of the brain in their relation to the cranial bones. I am indebted for these two illustrations to Flechsig's kind co-operation. With the aid of these it will be possible to expose with the trephine special areas of the cortex in case of disease or injury of the same. The different cortical areas are represented in the same way and with the same characters as in Fig. 56 (page 89).

The following brief remarks will serve as a general guide, and while reading them it would be a good plan to have a skull in the hand :

On the lateral surface of the skull is situated the fissure of Sylvius at a point corresponding to the junction of the greater wing of the sphenoid with the squamous suture. It divides here into the anterior ascending or short branch (ramus anterior) and the longer posterior or horizontal branch (ramus posterior). On both sides of the lowest portion of the coronal suture is situated the third frontal convolution with the area of motor aphasia (see Fig. 79, especially at that point where the linea semicircularis crosses the frontal suture. Further upward above the linea semicircularis, and in the vicinity of the coronal suture, is found the lower frontal sulcus, and some-

what farther backward in the lower portion of the anterior central convolution, and just above the linea semicircularis, is the motor centre of the facial (Fig. 79 ⊖) and hypoglossal (Fig. 79 ⦶) nerves. The upper temporal convolution between the posterior branch of the fissure of Sylvius and upper temporal sulcus with the second cortical speech-centre (sensory or auditory aphasia with word-deafness [Fig. 79 ✕]) begins at about the junction of the

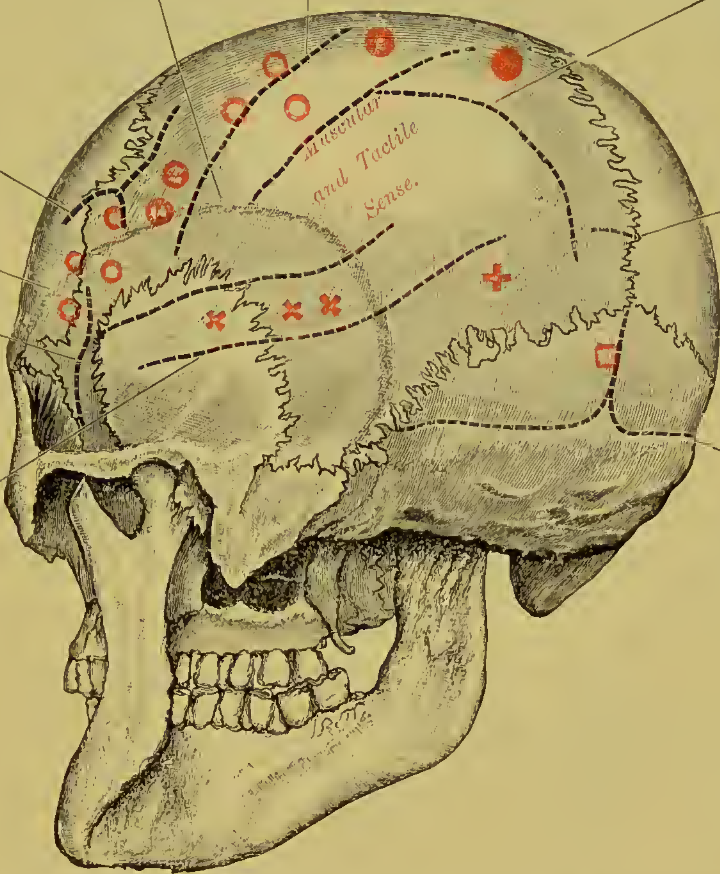


Fig. 79.—Schematic representation of the cortex with its centres and most important sulci in their relation to the cranial bones.

⊖ Motor cortical centre for the facial nerve.
⦶ Motor cortical centre for the hypoglossal nerve.
○ Motor cortical centre for the upper extremity.
● Motor cortical centre for the lower extremity.
o (Third frontal convolution) Motor aphasia.
✕ (Upper temporal convolution) Sensory aphasia with word-deafness.
+ (Gyrus angularis) Sensory aphasia with word-blindness.
□ (Upper occipital convolution) Visual area.

greater wing of the sphenoid with the squamous suture and runs obliquely upward over the linea semicircularis to the parietal bone.

On both sides, above and below the occipital suture and corresponding to the lower portion of the parietal bone and upper portion of the occipital bone, is situated the centre for vision (Fig. 79 □). Obliquely forward from the

visual area and in the angular convolution is found the third cortical speech-centre (sensory aphasia with word-blindness [Figs. 79 and 80 +]).

Beneath the parietal bone lies the motor area for the upper and lower extremities in the anterior and posterior central convolution as far as the parietal convolution and anteriorly in the paracentral gyrus (see Fig. 79 ○ ●

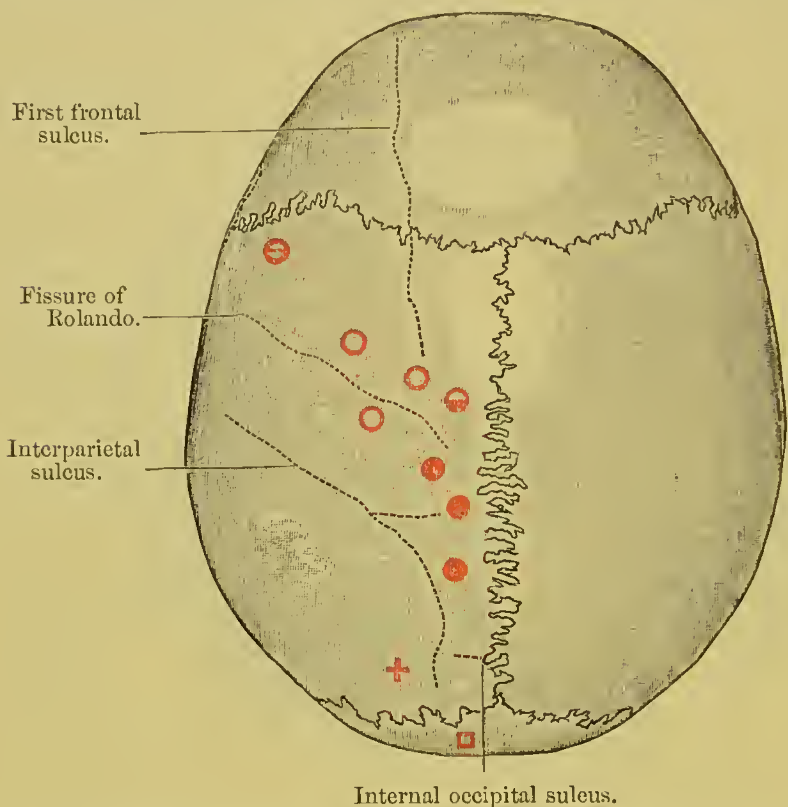


Fig. 80.—Schematic representation of the cortex with its most important sulci and centres in their relation to the parietal bone.

⊖ Motor cortical area for the facial nerve.
○ Motor cortical area for the upper extremity.
◒ Motor cortical area for the upper and lower extremity.
● Motor cortical area for the lower extremity.
+ (Gyrus angularis) Sensory aphasia with word-blindness.
□ (Upper occipital convolution) Visual area.

and Fig. 80 ○ ◒ ●). Farther backward and downward in the vicinity of the interparietal fissure is situated the centre for muscular and cutaneous sensation.

Topography of the Cerebral Convolutions with Reference to Surgical Operations.—In recent times attempts have been made in various ways to locate on the skull the position of the most important portions of the cortex.

In the first place, it is of the greatest importance to determine the location of the fissure of Rolando with its surrounding motor areas. Unfortunately, its position is not constant. According to Heffter, the upper end is 4·8 centimetres distant from the coronal suture and the lower end 2·8 centimetres. Generally speaking, the continuation of the fissure of Rolando, whose posi-

tion is not quite constant, strikes the centre of the sagittal suture. Thane's method, as described by Horsley, for determining the direction and upper end of the fissure of Rolando is as follows: One measures the distance between the root of the nose and the external occipital protuberance, and half an inch behind the centre of this line is situated in adults the median end of the fissure of Rolando. From this point the fissure runs forward, forming an angle of 67° with the sagittal suture. For this measurement Horsley uses a narrow strip of tin, to which a shorter strip is attached half an inch behind the centre at an angle of 67°. According to the measurements made by Anderson and Makins, the size of this angle varies between 55° and 70°.

The fissure of Sylvius, which is next in importance, is determined, according to Horsley, by dropping a perpendicular from the junction of the upper temporal ridge and the coronal suture to the zygomatic arch and bisecting this line. From this point the fissure runs just above the squamous suture to the parietal eminence. I also found the fissure just below the squamous suture (see Fig. 79).

Reid marks out the fissure of Rolando, and the fissure of Sylvius with its two limbs, in the following way (see Figs. 81 and 82): A line passing from the lower border of the orbit through the centre of the external auditory meatus is taken as the base line (C B). Close above this line in the occipital region lies the lateral sinus, or the boundary between the cerebrum and cerebellum. The horizontal limb of the Sylvian fissure (S H) lies beneath the posterior three fifths of a line which runs from the zygomatic process of the frontal bone to a point 1·5 centimetre below the parietal eminence. The ascending limb of the Sylvian fissure passes upward from this line over the middle of the zygomatic arch. A perpendicular line, D F, dropped from in front of the external auditory meatus on to the base line intersects the line for the fissure of Sylvius at E, the point where a continuation of the fissure of Rolando, E J, would join the horizontal limb of the fissure of Sylvius. The direction and position of the fissure of Rolando are obtained by drawing a perpendicular line from the posterior border of the mastoid process to the sagittal suture which it intersects at J. The line E J drawn from J to the point E on the Sylvian line gives the direction and position of the fissure of Rolando. The two central convolutions take up about an inch on each side of the line E J. The inferior temporal ridge corresponds approximately to the sulcus between the middle and lower frontal

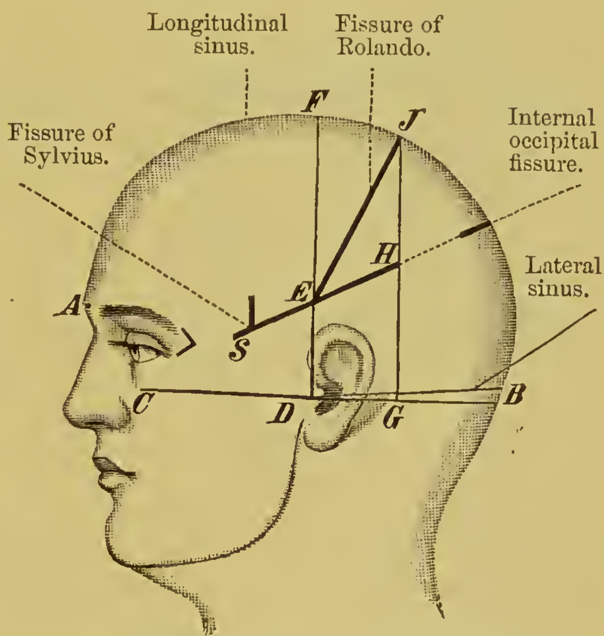


FIG. 81.—Reid's method of determining the position of the fissures of Rolando and Sylvius: EJ, fissure of Rolando; SH, fissure of Sylvius.

convolutions (Fig. 82). The angular convolution lies immediately behind the parietal eminence (Fig. 82, G *a*), above the continuation of the Sylvian line. If one continues the Sylvian line backward as far as the sagittal suture, it intersects the interparietal fissure and meets the perpendicular occipital sulcus (Fig. 82).

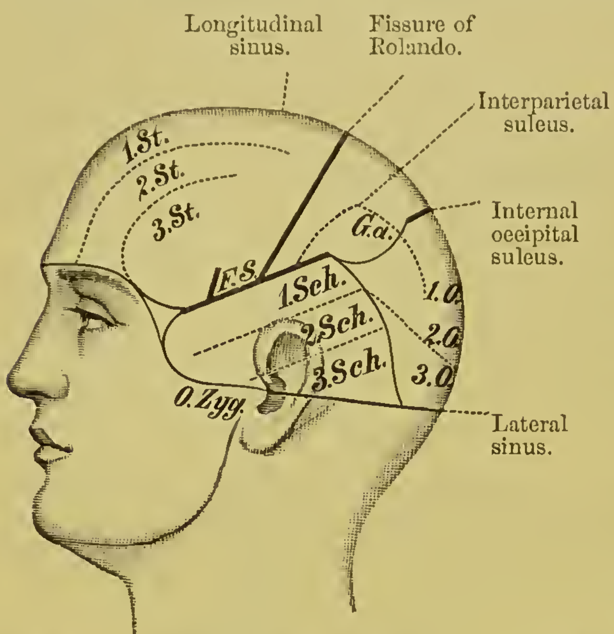


FIG. 82.—Topography of the cortex (Reid). *1.St.*, *2.St.*, *3.St.*, first to third frontal convolution; *F.S.*, fissure of Sylvius; *G.a.*, gyrus angularis; *1.—3.Sch.*, first to third temporal convolution; *1.0.—3.0.*, first to third occipital convolution. The basal line runs above the malar bone.

Anderson and Makins have proposed the following external lines (see Fig. 83): From the centre of the glabella—i. e., from the centre of a line (A) running tangential to both eyebrows—a line is drawn to the external occipital protuberance (B), which is halved, and the half-way point (C) is united with a point (D) situated just in front of the ear on a level with the upper wall of the external auditory canal. The lower third of the line C D is marked off at E (D E), and then the line F E is drawn from the point F, the most prominent point on the outer border of the orbit at the outer extremity of the eyebrows. This last line gives the direction of the horizontal limb of the fissure of Sylvius. The upper end of the fissure of Rolando is found at G, about one centimetre behind C, and runs from here in the direction G H, H being on the line E F about one centimetre in front of E. The upper boundary of the cuneus or the perpendicular occipital fissure O is obtained by marking off five twelfths of the distance from B to C—i. e., B O is equal to five twelfths B C. Hence, according to Anderson and Makins, the perpendicular occipital fissure does not lie in a continuation of the horizontal limb of the Sylvian fissure, but below it. Both measurements are right, according to my investigations.

According to Poirier, the upper end of the fissure of Rolando lies two centimetres posterior to the middle of the distance in a sagittal direction between the naso-frontal suture and the external occipital protuberance, or eighteen centimetres from the naso-frontal suture, and in small skulls seventeen centimetres. The lower end of the fissure of Rolando lies in a perpendicular line meeting the horizontal portion of the upper border of the malar bone just in front of the tragus in the depressio præauricularis, and seven centimetres above the horizontal. For determining the position of the fissure of Sylvius, Poirier draws a line through the frontal suture and the lambda (which lies seven centimetres above the external occipital protuberance); this runs about seven centimetres above the external auditory meatus. This line follows for four to six centimetres the outer portion of the fissure of Sylvius.

If a line is drawn from the upper border of the zygomatic arch to the external occipital protuberance, the cerebellum lies below and the lateral sinus above this line (see also Fig. 81).

Le Fort draws the following topographical lines: 1. The sagittal line from the glabella to the external occipital protuberance. On this line the lambda lies sixty-seven to seventy millimetres above the external occipital protuberance. The distance from the upper end of the fissure of Rolando to the glabella along this line is equal to $\frac{532}{1000}$ of the whole length of the line. It varies between 154 and 191·5 millimetres in a variation of the whole length from 290 to 360 millimetres. 2. The line joining the uppermost point of the fissure of Rolando with the middle of the zygomatic arch represents the direction of the fissure of Rolando (*ligne rolandique*). The lower end of the fissure of Rolando is situated on this line about ten to fifteen millimetres above the point of intersection with the following line. 3. The line connecting the zygomatic process of the frontal bone and the lambda corresponds, at a distance of twenty-seven millimetres from the anterior extremity of the line, to the fissure of Sylvius for from four to six centimetres.

Of the various measuring apparatus, the one shown in Fig. 84, which gives Reid's lines as described above, is especially to be recommended. An

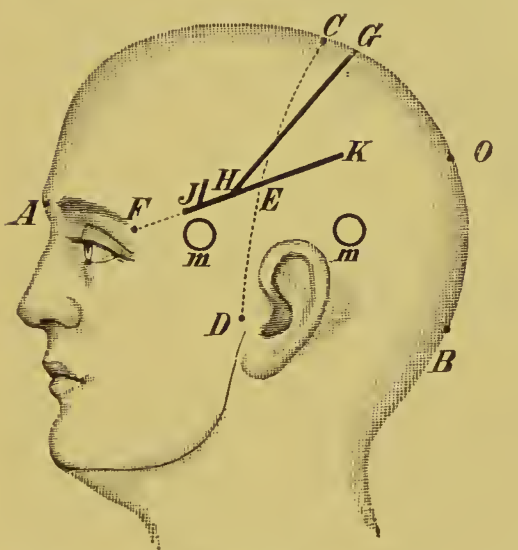


Fig. 83.—The method used by Anderson and Makins of determining the fissure of Rolando, *H G*, and the fissure of Sylvius; *m m*, middle meningeal artery.

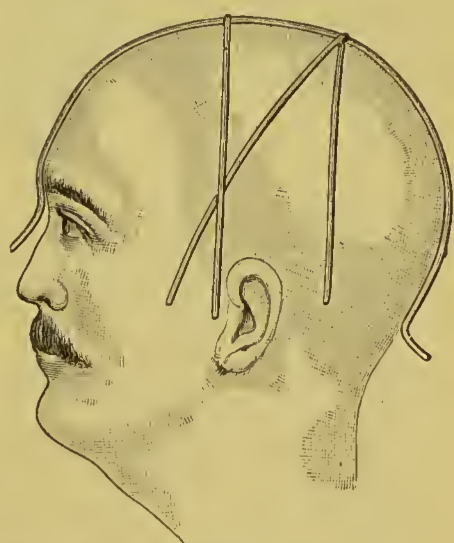


Fig. 84.—Craniometer devised by Reid and Koehler.

apparatus of this sort has recently been described by Koehler. It is made of flexible, easily sterilized hoop-iron, which is marked off into centimetres. The two cross-pieces can be pushed along the longitudinal piece. The strip which corresponds to the fissure of Rolando is fastened to the longitudinal piece by a sort of joint. This pliable apparatus can be fitted to any head.

At first the longitudinal strip is adjusted to the distance between the glabella and the external occipital protuberance, and then the two cross-pieces corresponding to Reid's above-mentioned vertical lines are applied in front of the external auditory meatus and at the posterior border of the mas-

toid process. The further measurements can be determined from Reid's lines. I have constructed a very similar apparatus, marked off into centimetres.

The apparatus devised by Kocher and Schenck also seems to me a good one (Fig. 85). It consists of two steel strips, capable of clasping the head, and an elastic band (*a i z b*) made to pass horizontally about the forehead, temples, and occiput. The latter passes transversely around the skull from *a* (a thumb's breadth above the root of the nose) to *b* (the lowest point of the occipital protuberance) directly over the upper insertion of the auricle. The steel strip *a d c e f b*, placed along the sagittal meridian, is connected with a second strip (*c g h i* or *c s t v*) which is marked off with degrees. The latter can

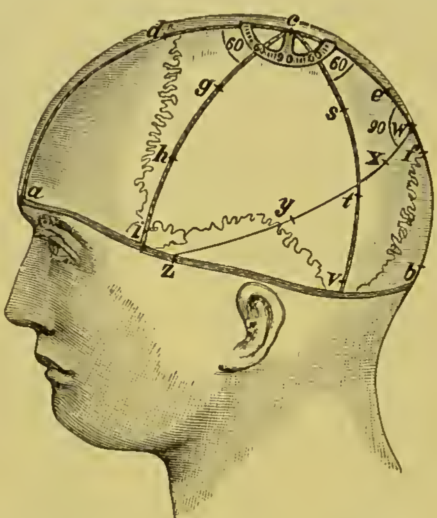


Fig. 85.—Craniometer of Kocher and Schenk: *a*, "crista" glabellæ, a thumb's breadth above the root of the nose; *b*, lowest point of the occipital protuberance; *c*, centre of *a b*; *d*, one third of distance from *a* to *b*; *e*, two thirds of distance from *a* to *b*; *f*, three fourths of distance from *a* to *b*. The oblique meridians *c g h i* and *c s t v* are drawn from *c*, each at an angle of 60°. The line *w x y z* runs from *w*, the central point of *e f*, at an angle of 90°; *z* is one centimetre behind *i*.

Of the above letters the following represent certain points on the surface of the brain: *a*, anterior pole of the frontal lobe; *b*, about one centimetre below the posterior pole of the occipital lobe; *i*, anterior end of the fissure of Sylvius where its horizontal limb joins the ascending limb; *v*, boundary between the temporal and occipital lobes; *c*, summit of the anterior central convolution in front of the fissure of Rolando; *g*, juncture of the anterior central convolution with the first and second frontal convolutions; *h*, juncture of the anterior central convolution with the second and third frontal convolutions; *s*, upper parietal lobe above the sulcus interparietalis; *t*, posterior end of the first temporal sulcus below the gyrus angularis; *w*, apex of the lambdoid suture of the skull or the parieto-occipital fissure of the cortex; *x*, gyrus angularis; *y*, posterior termination of the horizontal portion of the fissure of Sylvius; *z*, anterior termination of the first temporal sulcus; *a*, foot of the first frontal convolution; *b*, boundary between cerebrum and cerebellum.

be placed at any desired portion of the sagittal meridian and at any angle to the same—i. e., to the line *a d c e b*. With the aid of the lateral strip one determines from *c* (the centre of *a b*) forward and backward at an angle of 60° the oblique meridians *c g h i* and *c s t v*, and likewise from *w* (half of *e f*) at an angle of 90° the line *w x y z*. The two oblique meridians *c g h i* and *c s t v*, as well as the line *w x y z*, are divided into three equal parts, and in this way the chief points on the surface of the brain can be accurately marked out (see Fig. 85).

Appendix.

Anatomy and development of the frontal sinuses.—Injuries.—Foreign bodies.—Inflammatory processes (catarrh, dropsy, empyema).—Tumours.—Catheterization and illumination of the frontal sinuses.

§ 24. **Injuries and Diseases of the Frontal Sinuses.**—For an understanding of the injuries and diseases of the frontal sinuses an exact knowledge of their anatomy and development are of great importance.

The frontal sinuses belong to the accessory cavities of the nose, and, like all accessory cavities of this organ, are at first circumscribed pouches of the nasal mucous membrane covered with cartilage, which have no connection with the neighbouring bone (Dursy, Kölliker). The cartilaginous capsules disappear finally, and cavities are formed in the overlying bone to receive the mucous-membrane sacs which have gone on increasing in size. These cavities are formed by the absorption of bone. Of the accessory cavities of the nose, the ethmoidal cells and the antrum of Highmore show the first rudiments in a six-months-old fœtus. The development of the former goes on quickly while that of the antrum of Highmore is much slower. The development of the sphenoidal cells and the frontal sinuses does not begin until after birth and is very variable. The latter are the last of all the accessory cavities to develop, and increase the most slowly in size. The development of the frontal sinuses as regards time and size is extremely variable. It is usually stated that in the sixth to the seventh year they should be about the size of a pea, but not infrequently it is found that even in the twentieth year their development has just begun from divergence of the two lamellæ of the frontal bone. Occasionally they are absent altogether. Their development seems to be especially retarded by the persistence of the frontal suture. Among twenty skulls with a frontal suture, the frontal sinuses were entirely wanting in four, and in five they were present only on one side (Welcker). Their size is very variable. There is, unfortunately, no method by which it is possible to recognise and measure their extent from the outside. Hamilton obtained the following averages for the size of the frontal sinuses: two and two fifths inches wide, one and a half inch high, and four fifths of an inch deep. The septum between the two sinuses, which is sometimes wanting, is only rarely found in the median line, but is often pushed some distance toward one side or the other, or it is noticeably oblique. They sometimes reach a very great size, and in some instances have been found to extend to the neighbourhood of the frontal eminences, into the roof of the orbits, and into the external angular process. In the hog and elephant it is the rule to find extremely large frontal sinuses, and in fact the shape of the elephant's head is largely due to their size.

Injuries of the Frontal Sinuses.—Fractures of the anterior wall of the frontal sinuses are mainly caused by direct violence. Fractures of the posterior wall have already been mentioned in connection with fractures of the base of the skull. After simple fractures of the an-

terior wall emphysema is usually observed in the vicinity of the forehead, eyelids, and cheeks, produced mainly by blowing the nose. In an exceptional case Desprès observed a subcutaneous emphysema of almost the entire surface of the body, resulting from a fall upon the frontal region. If one directs a patient with a simple fracture of the anterior wall of a frontal sinus to close the mouth and nostrils and then blow, one can locate more exactly the injury at that point where air is driven out beneath the skin. Even deep depressions of the frontal sinuses in fractures of the skull often involve only the anterior wall, and the posterior wall may remain intact, so that the fracture does not penetrate into the cranial cavity.

Wounds or compound fractures which opened the frontal sinuses were at one time erroneously regarded as especially dangerous. The main point is whether the posterior wall is injured and in this way the cranial cavity opened. If this is the case, death from suppurative meningitis can easily occur from the entrance of pyogenic microorganisms, from the frontal sinuses into the cranial cavity (see § 9, Fractures of the Base). In open wounds of the sinuses air escapes externally when the patient blows his nose. If, on the other hand, the mucous membrane of the frontal sinus has been exposed by an injury but is intact, one sees, corresponding to the respiration, a rhythmic rise and fall of the exposed mucous membrane which has even been mistaken for prolapse of the brain. After the frontal sinuses have been opened fistulæ sometimes result, especially in the case of wounds with a loss of tissue and necrosis due to compound comminuted fractures. If their anterior wall has been largely destroyed, they may become completely obliterated by the formation of granulations and approximation of the walls.

Foreign bodies, such as bullets, spear-tips, etc., often remain for years within the frontal sinuses, and are discharged spontaneously through the anterior or posterior nares. Occasionally foreign bodies have given rise to profuse suppuration, resulting in death from meningitis or abscess of the brain. As regards insects in these cavities the reader is referred to page 177.

The treatment of fractures and wounds of the region of the frontal sinuses follows the general rules for fractures of the skull. For emphysema the application of a compressive bandage is advisable. Depressed fractures of their anterior wall can be left alone, and only in case of splintering of the posterior wall with corresponding focal symptoms should operative measures be adopted and the fragments removed. One should always provide for a sufficient escape of the secretion from the sinus toward the nose, and if necessary in compound fractures, a

drainage-tube may be passed from the sinus into the nose as far as its external opening. It is a very good plan, in fractures of the posterior wall, to pack the sinus with sterile iodoform gauze, after chiselling it open or enlarging the hole in its anterior wall. Defects in the anterior wall may be covered with plastic flaps of skin and periosteum.

Diseases of the Frontal Sinuses.—Of the diseases of the frontal sinuses I shall mention first catarrh of these cavities, secondary to catarrh of the nose, and causing a characteristic headache in this region. In consequence of swelling of the mucous membrane, due to a catarrh of long standing or other inflammatory processes, or tumours of the nasal cavity or frontal sinuses, the outlet toward the nose may become plugged up, and, owing to the accumulation of a mucous or purulent secretion, dropsy or empyema of the frontal sinuses may ensue, with secondary gradually increasing distention of the same. The dilatation takes place mainly toward the orbits, so that the bulb may become displaced outward and downward.

An accumulation of blood (hæmatoma of the frontal sinuses) has been observed to cause a marked distention of the sinus in question (Billroth).

Empyema or abscess of the frontal sinuses usually originates from some process within the nasal cavity which may be a severe infectious inflammation, involving not only the sinuses, but also the Eustachian tubes, middle ear, and both antrums of Highmore. It may also be the result of tubercular or syphilitic caries and necrosis, of injuries, foreign bodies, and tumours (see below). Insects, such as the *diptera* larvæ, and the *scolopendra*, have been known to cause persistent and very painful suppuration within the frontal sinuses.

The symptoms of empyema depend upon whether it is an acute or chronic process. In the acute collections of pus the pain, swelling, ocular and nasal disturbances, etc., begin much more suddenly and violently, usually with the symptoms of fever, while in the chronic cases a dull, unpleasant feeling in the frontal region, and a more profuse secretion from the nose, are present for some time before the swelling. As long as the purulent discharge escapes through the nose, headache is usually the only symptom. If, however, retention of the secretion takes place from swelling of the mucous membrane of the nose and frontal sinuses in the vicinity of their outlet, or from inspissation of the pus, the sinuses may gradually become enlarged and the bony walls grow constantly thinner. At times the outlet may become patent again, resulting in the discharge of large amounts of pus. Moreover, when the patient blows his nose, a considerable discharge of pus takes place. Finally, the empyema may perforate externally or into the nose, orbit,

or cranial cavity, and when the latter occurs death may result from acute meningitis or sinus thrombosis with pyæmia. If the sinus becomes enlarged toward the orbit, the bulb becomes correspondingly affected, being displaced downward and outward, and diplopia results, followed often by blindness from atrophy of the bulb. If the abscess perforates into the orbit, suppurative periostitis of the roof of the orbit with secondary orbital cellulitis may follow. The anterior wall becomes sometimes so thin that it crackles on pressure. In consequence of perforation of the anterior wall of the sinus, air may collect beneath the skin of the forehead, forming a tympanitic swelling, as in Warren's case (Fig. 86). For a description of collections of air beneath the scalp (pneumatocele capitis, pneumatocele sincipitalis) see page 22.

FIG. 86.—Pneumatocele capitis in a man of forty-five due to necrosis of the walls of the frontal sinuses following traumatic suppuration (Mason Warren).

Of the complications that have been mentioned, the cerebral disturbances are the most important, which sometimes begin with anæmia and optic neuritis. Of forty-eight cases of empyema of the frontal sinuses collected by A. Richards, six proved fatal, and of these, four died of brain abscess, one of meningitis, and one of albuminuria.

The treatment of empyema of the frontal sinuses should begin with a treatment of the nasal catarrh by means of astringent irrigations, nasal douches, cauterization of the nasal mucous membrane, etc. Politzer's method (see Diseases of the Ear) is also of use in removing the plugs of purulent material. Of late, catarrhal and suppurative processes in the frontal sinuses have been successfully treated by passing a small silver tube up through the nose into the sinus and irrigating it (Jurasz, Hartmann, Choleva). This manœuvre (see page 181), however, as Katzenstein also says, is, even under normal conditions, not easy and may be impossible. Schäffer, Winckler, and others recommend perforation of the floor of the sinus by means of a metallic probe passed up along the dorsum of the nose, between the septum and middle turbinated bone. The interior of the nose should first be cocainized. The sinus is then irrigated by means of a curved tube. I have found that the best way is to open the sinus from in front by means of the chisel and mallet. The dimensions of the frontal sinuses

are, as we saw on page 175, very variable, and there are no external landmarks corresponding to this variation in their size. One is surest to strike the frontal sinus by applying the chisel somewhat obliquely at a point above, and to the outer side of the root of the nose just over the inner portion of the eyebrows and to one side of the middle of the frontal bone. If there is already a defect in the anterior wall of the frontal sinus, the latter is exposed by an incision, and the opening in the bone enlarged, when necessary, with a rongeur forceps or chisel. The same method is pursued in case of a fistula. After opening the frontal sinus, the discharge of the pus into the nasal cavity must be re-established by pushing through the normal outlet on the lower inner wall of the sinus a large probe, trocar, small sharp spoon, or small knife, thus forming a sufficiently wide communication between the frontal sinus and nasal cavity. For the first few days a drainage-tube is passed through from the frontal sinus to the outer nasal opening.

Dropsy of the frontal sinuses develops in much the same way as empyema by the accumulation of mucus due to closure of the outlet into the nose, and is very frequently combined with the formation of mucous polyps and mucous cysts. Occasionally an echinococcus cyst is found.

The treatment of dropsy is similar to that of empyema. Any mucous polyps that may be present should be thoroughly removed (see also Nasal Cavity).

Tumours of the Frontal Sinuses.—The tumours of the frontal sinuses are mucous polyps, mucous cysts, fibrous polyps, carcinomata, and, most frequent of all, osteomata. Weinlechner observed a cholesteatoma following a chronic empyema of the frontal sinus. All these tumours may cause the frontal sinuses to become very much distended.

Among the neoplasms of the frontal sinuses, the osteoma is the most common. Bornhaupt collected from literature, in addition to a case of Volkmann's, twenty-three cases of osteoma. They are not infrequently observed in the other accessory cavities of the nose, including the ethmoidal and sphenoidal cells, antrum of Highmore, and in the nasal cavity itself. They develop most frequently in the ethmoid bone and grow from here into the frontal sinuses, or more rarely the nasal cavity. In the same way an osteoma may originate in the sphenoid bone or the different accessory cavities of the nose. The frequency with which osteomata develop in the ethmoid bone is explained by the fact that remains of fœtal cartilage persist for a long time here, and form the nuclei of osteomata. Osteomata begin, as a rule, as enchondromata and then become ossified by degrees. They develop principally in early life, and are usually characterized by a very

slow growth. They can be mistaken at first sight for polyps, as they are generally covered with mucous membrane. They sometimes perforate the walls of the frontal sinuses and grow into the neighbouring

Fig. 87.—Dilatation of the right frontal sinus in a girl sixteen years of age caused by the growth of a mucous cyst (Barckhausen and Steiner).

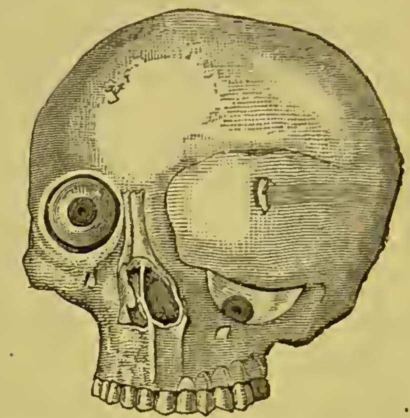


Fig. 88.—Dilatation of the left frontal sinus in a girl of fourteen with perforation into the cranial cavity caused by the growth of a mucous cyst (Jäger and Steiner).

cavities, especially the orbit (see Fig. 89), nose, and cranial cavity, and cause corresponding symptoms, such as neuralgia of the supra-orbital nerve, disturbances of vision going on to complete blindness, paralyses, meningitis, brain abscess, etc.

It is of special interest to note that osteomata of the frontal sinuses and the other accessory cavities of the nose sometimes become sepa-

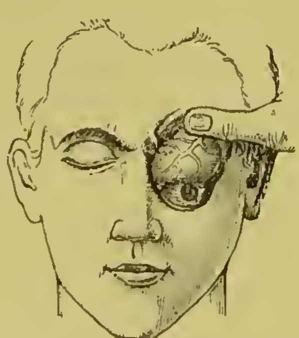


Fig. 89.—Osteoma of the left frontal sinus which has grown into the orbit in a peasant of eighteen; extirpation; death from meningitis (Banga).

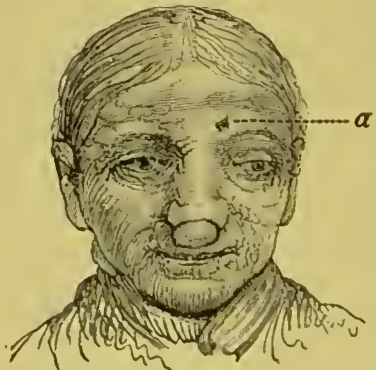


Fig. 90.—Necrotic osteomata of the left frontal sinus and osteoma of the naso-pharynx in a peasant woman of fifty-three: *a*, fistula passing into the left frontal sinus; recovery.

rated at the point of attachment of their pedicle as the result of suppuration, necrosis, pressure atrophy, and more rarely traumatism. One then finds necrotic concretions of bone (dead osteomata) lying completely free in the sinus (Dolbeau, author). I removed two dead osteo-

mata from the frontal sinus of a fifty-three-year-old peasant woman, and a third from the nasal cavity. The tumours had developed early in life. The two bony concretions in the frontal sinus were the size of a pigeon's egg and walnut respectively. The one in the nasal cavity protruded through the external nasal opening and extended back to the posterior wall of the pharynx. All three had originated in the ethmoid bone (see also Langenbeck's Archiv, Bd. xxxii).

Osteomata of the frontal sinuses and other tumours are to be removed by chiselling open the sinuses, especially if they cause much trouble, or the sight or life of the patient is endangered. According to Berlin, the mortality of operative removal of osteomata of the frontal sinuses is thirty-eight per cent (meningitis). In my opinion, the removal of osteomata of the frontal sinuses should never be delayed too long, as it is probably for this reason that the operation has such a high mortality. The strictest asepsis must, of course, be observed.

One is surest of finding the frontal sinuses by going in above and to the outer side of the root of the nose, and to one side of the median line of the frontal bone (see page 179).

For air tumours of the frontal sinuses (pneumatocele capitis or sincipitalis), see page 23 and page 178, Fig. 86.

Catheterization of the Frontal Sinuses.—Jurasz, Choleva, Katzenstein, Hartmann, and others have catheterized the frontal sinuses in several instances from within the nasal cavity. It is indicated particularly in catarrhal and suppurative inflammations of these cavities. Jurasz recommends for this purpose extremely thin silver probes with a knob at the end or fish-bone probes. It is difficult to find the communicating opening (naso-frontal duct) between the nose and frontal sinus, as its position varies very much. The front portion of the infundibulum in the anterior extremity of the middle turbinated bone is always the place to look for the orifice of the canal leading from the frontal sinus. One finds first the anterior beak of the middle turbinated bone; between this and the uniform process of the ethmoid bone the infundibulum forms a fossa, and the upper rounded-off part of this fossa is the mouth of the canal. The canal, which is partly straight and partly curved, is, according to Hausberg and Choleva, three to ten millimetres in length, and according to others as much as twelve to sixteen millimetres. The entrance into the naso-frontal duct

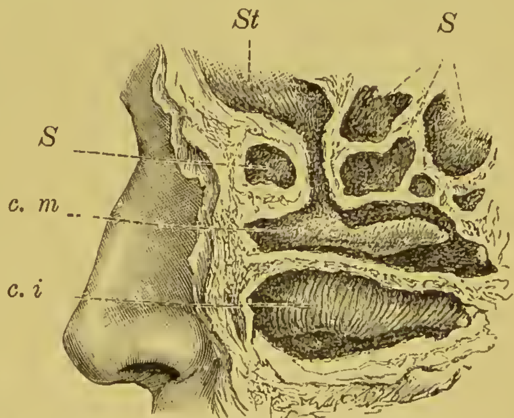


FIG. 91.—Orifice of the naso-frontal duct of the frontal sinus *St* in the vicinity of the middle turbinated bone *c m*; *c i*, lower turbinated bone; *S*, ethmoidal cells (the outer wall is removed showing the nasal meatuses, the ethmoidal cells, and the frontal sinus).

may be made difficult by an abnormal prominence of the middle turbinated bone, the unciform process, and the bulla ethmoidalis (Hartmann). If the frontal sinus can be reached with sufficient ease from the nasal cavity, an empyema can be cured by catheterizing the sinus or perforating the floor of the same and irrigating it without opening it from in front. The surest method, however, of treating diseases of the frontal sinuses, especially empyema, is, according to my experience, to open the frontal sinus from in front, and secure free drainage by enlargement of the outlet into the nose with a trocar, for example, or a sharp spoon.

Vohsen has devised a special apparatus for illumination of the frontal sinuses similar to that for illuminating the antrum of Highmore (see Berliner klinische Wochenschrift, 1890, Nos. 12 and 46).

CHAPTER IV.

INJURIES AND DISEASES OF THE FACE (ORBITAL REGION, CHEEKS, LIPS).

Congenital malformations of the face (harelip, and other fissure formations and deformities).

Injuries of the soft parts of the face (wounds, cephalic tetanus, burns, frostbite).—Ligation of the arteries of the face.

Diseases of the soft parts of the face: Furuncle.—Carbuncle.—Malignant pustule.—Glanders.—Noma.—Sycosis.—Eczema.—Erysipelas.—Lupus.—Syphilis.—Tumours.—Pulsating exophthalmos, and other surgical diseases of the orbit.—Enucleation of the eyeball. *Plastic operations* on the face: Blepharoplasty (formation of a lid), cheiloplasty (formation of a lip), stomatoplasty (formation of a mouth), meloplasty (formation of a cheek).

§ 25. **Congenital Malformations of the Face.**—Congenital malformations of the face are due to disturbances in its normal development in the first weeks of fœtal life.

There are formed in the fœtus, near the end of the second week, four deep clefts on each side below the cephalic extremity—the so-called visceral or branchial clefts. It was formerly supposed that the branchial clefts in birds and mammals were complete fissures. His, however, has shown that they are only furrows or pockets, which are closed by delicate membranes consisting at the thinnest parts only of the ectoderm and entoderm of the pharynx. Born, Kölliker, and others have since adopted this view of His. The designation branchial furrow is therefore more accurate. In pathological cases a branchial furrow may no doubt break though into the pharynx—e. g., in a congenital fistula of the neck that does not end blindly (see Neck).

There goes hand in hand with the formation of these branchial furrows the appearance of the so-called visceral or branchial arches, inasmuch as the tissue between the furrows becomes thickened from behind forward. The first of these branchial arches lies between the oval aperture and the first branchial furrow, the second between the first and second furrows, the third between the second and third, and the last, the fourth, between the third and fourth furrows.

The neck is formed by the coalescence of the three lower branchial arches in the median line and with one another.

The face is formed by the coalescence of various processes which grow out from the first or mandibular arch and from the frontal portion of the skull in the neighbourhood of the buccal cleft (see Fig. 92). The superior maxillary process grows out of the first branchial arch backward and upward

from the buccal cleft. The frontal process grows down from above, between the two superior maxillary processes. This frontal process is then divided into a middle process and two lateral ones. The middle frontal process is separated from the lateral one on each side by the nasal furrow. The middle frontal process is then again divided into halves by a median incisure. From the superior maxillary processes which grow upward laterally from the buccal cleft, the cheeks, the lateral portions of the upper lip, the upper jaw, and the two halves of the soft palate are formed. The frontal process contains the anlage of the external nose, the ethmoid bone and cartilaginous septum, the lacuna of the upper lip, the intermaxillary bones, and the vomer. The first branchial arch subsequently becomes the lower jaw and floor of the mouth. The tongue grows from the region of the three superior branchial arches into the oral aperture. From coalescence of the parts named with one another and in the median line, the anterior wall of the face is formed in which the nares and the oral aperture persist as remains of the wide-open buccal cleft.

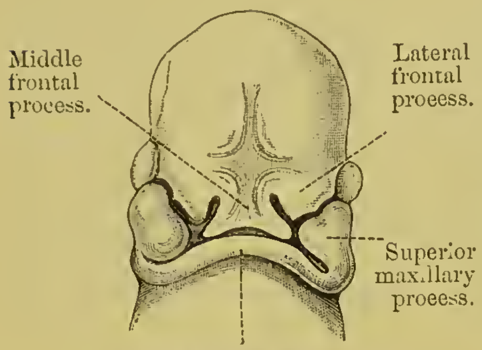


Fig. 92.—Head of the fœtus of a rabbit fourteen days old (His).

All the branchial clefts disappear in the course of the later development of mammals and birds except the first, from which are formed the external auditory canal, the cavity of the tympanum, and the Eustachian tube.

The congenital malformations of the face owe their origin to the above-mentioned fœtal clefts. If coalescence of the edges of the fœtal clefts does not take place, abnormal fissures result. If the coalescence exceeds the normal limits, so-called atresiæ result.

The causes of malformations of the face are not well understood. It is perhaps owing to mechanical factors that the coalescence of the single parts is prevented—e. g., the interposition of portions of tissue in the fœtal clefts or furrows, or abnormal intracranial pressure (hydrocephalus, cephaloceles). Hereditary transmission is comparatively frequent, through the mother chiefly, and but rarely through the father.

Harelip.—The most common congenital fissure formation is harelip, in which there is a fissure of the upper lip which is frequently combined with a cleft of the alveolar process and the hard and soft palate, the so-called cleft palate. The fissure in the lip and in the bone almost always lies to one side of the median line, whereas the cleft of the soft palate and the uvula is always in the middle, since the latter arise from direct union of the palate processes in the middle line without co-operation of the frontal process.

Harelip is caused by defective or complete absence of coalescence of the middle frontal process with the superior maxillary process (Th. Kölliker), or by the failure of the lateral frontal and the middle frontal

processes to unite (Albrecht, see Fig. 92). It may be single or double, and incomplete or complete, reaching into the nostril (see Figs. 93, 94). Single harelip is more frequent on the left side, and occurs oftener in

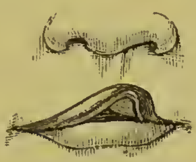


FIG. 93 *a*.

FIG. 93 *b*.

FIG. 93 *c*.

Various degrees of simple hare-lip.

boys than in girls. According to E. Müller, of two hundred and seventy cases, one hundred and seventy occurred in boys and one hundred in girls; and the cleft in the cases of single harelip occurred one hundred and forty-two times on the left side and only sixty-two times on the right side. In cases of incomplete fissure of the lip, a cicatricial line sometimes extends upward from the cleft similar to the rhaphe on the perinæum. Trendelenburg properly emphasizes the fact that histologically no true cicatrix can be demonstrated, but that coalescence of the tissue is here altogether normal. Something similar is observed

FIG. 94 *a*.

FIG. 94 *b*.

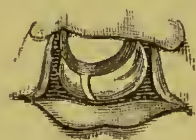


FIG. 94 *c*.

Various degrees of double hare-lip.

also in oblique facial clefts (see Fig. 100, page 189) and in clefts of the palate.

As has been said, harelip is often combined with cleft of the alveolar process and of the hard and soft palate (cleft palate, or wolf's jaw).

Clefts in the alveolar process vary very much in length and breadth. They either terminate in the region of the anterior palatine canal or extend farther into the hard palate.

To the single or double fissure of the alveolar process is often added a single or double cleft of the hard palate, which may then continue on to a complete or incomplete cleft of the soft palate, which is always single and situated in the middle line.

In double harelip especially, with or without cleft palate, the intermaxillary bone is sometimes pushed forward by the vomer so as to form a protrusion resembling a "pope's nose" or snout (see Fig. 95).

In other cases of double harelip the intermaxillary bone is in line with the alveolar arch, whereby the operation for closure of the labial cleft is naturally made much easier.

Clefts of the palate also frequently occur independently of harelip or fissure of the alveolar arch. Clefts of the hard palate arise when the two palate processes wholly or partially fail to unite. In cases of double cleft of the hard palate the vomer is not united with the two palate processes, but forms a ridge in the middle line between the two clefts. If there is no harelip or alveolar cleft, the cleft of the hard palate usually ends in the region of the anterior palatine foramen, where, as is known, the superior maxillary process and the frontal process unite.

Fig. 95.—Projecting intermaxillary bone.

Clefts of the soft palate, which are always single and situated in the median line, occur either by themselves or in conjunction with clefts of the hard palate, the alveolar process, and the upper lip. If the cleft in the soft palate is incomplete, one finds either a slitlike opening in the velum palati, while the uvula is normal, or the reverse is true, the cleft being confined to the latter. In case of clefts in the soft palate, its lateral portions are always more or less incompletely developed. In rare cases lateral defects occur also in the anterior palatine arches (Wolters, Cohen).

The fissure formations in the upper lip, the alveolar processes, and the hard and soft palate that have been mentioned are combined in the most varied manner, and each also occurs by itself. The most advanced degree of fissure formation is the double complete fissure of the lip, the jaw, and the palate.

According to Th. Kölliker and Biondi, the cleft in the lip and in the alveolar process is caused by the non-union of the middle frontal process and the superior maxillary process—that is, the cleft in the alveolar process, according to this view, lies between the intermaxillary and superior maxillary bones. According to the first author, the two lateral frontal processes have no share in the formation of the upper lip. According to Albrecht, on the other hand, the cleft of the lip and the jaw is caused by the non-union of the lateral and middle frontal processes. Albrecht assumes four intermaxillary bones, a middle and a lateral on each side, and the cleft in the jaw lies, according to his view, between these—that is, between the lateral and middle incisors. According to Albrecht, then, the superior maxillary process has nothing to do with the formation of the cleft in the lip and the jaw, but is concerned in the oblique facial cleft (see Fig. 98), which, according to his view, is caused by the non-union of the lateral frontal process and the superior maxillary process. Albrecht's statements have been fully corroborated by Meyer. The latter found, in the upper jaw of twenty-two newborn children

and fœtuses of from seven to nine months, a distinct suture between the outer and inner incisors, or, in other words, between the two intermaxillary bones on each side. Biondi also corroborates the occurrence of two intermaxillary bones on each side, one of which, however, originates from the superior maxillary process and the other from the frontal process. Albrecht's statements with reference to the location of harelip do not, to be sure, meet all cases. As Trendelenburg has stated, there are clefts of the jaw which run between the canine tooth and the lateral incisor. The location of the cleft is probably not always constant, as Morian has also stated, basing his opinion upon an interesting case.

Fig. 96.—Double harelip with absence of the intermaxillary bone.

In the worst cases of fissure formation the intermaxillary bones and the vomer are sometimes absent, so that beneath the nose there is a broad median defect (Fig. 96). Trendelenburg regards these as cases of double fissure formation, with absence of the middle piece. They are due to defective development of the middle frontal process. It is an interesting fact that the middle portion of the upper lip, the intermaxillary bones, the nasal septum, and the nasal bones may be entirely wanting, while in spite of this the two superior maxillary bones have firmly united (Engel).

In this connection should be mentioned the congenital atresia of the posterior nares in the early development of the middle portion of the skull.

In cases of defective development of the middle portion of the skull there are also, as a rule, congenital defects of the middle portion of the brain, while the lateral portions coalesce with one another, as sometimes happens also in the skull when the intermediate portion is absent. This malformation of the brain (arrhinencephalia) has been recently studied more in detail, especially by Kundrat. Defects in the brain also occur in connection with single cleft of the lip and palate without other cranial defects.

The formation of supernumerary teeth as a fœtal overproduction is sometimes observed in cases of cleft of the lip and jaw. This is analogous to the formation of auricular appendages in the vicinity of the first branchial arch.

Fig. 97.—Median fissure of the upper lip and deformity of the nose (Trendelenburg).

Of other fissure formations of the face I mention here, to begin with, the rare median cleft of the upper lip which usually extends through about half of it, and is sometimes combined (see Fig. 97) with the formation of a furrow on the nose, so that the nostrils are separated by a sulcus (Witzel). In complete median harelip the palate is usually cleft as well. The rare nasal fistulæ upon the dorsum of the nose and at the lower end of the nasal septum are to be regarded as the mildest grade of median facial cleft (Trendelenburg, Beely, Ruysch, Bramann). Congenital longitudinal cicatrices have also been seen upon the dorsum of the nose. The rare congenital labial

fistulæ deserve mention here. They are found on the lower lip, less often on the upper. They are situated in the vicinity of the median vertical groove of the lip, are lined with pavement epithelium, and contain sebaceous and mucous glands.

Witzel made a thorough examination of the skull of a newborn dog with a congenital median cleft of the upper half of the face. The real malformation was found to consist in a longitudinal fissure of the nose dividing the cutaneous and cartilaginous septum in the median line and continuing as far as the vomer, which was flattened but undivided. Between the halves of the nose, which were everted, the dura mater was found to protrude from above. Leuckart, Ammon, Albert, Poppe, and others have seen similar cases. The cause of the malformation is looked for by Witzel in the persisting palate process, which by its growth has forced the nose apart.

The rare lateral nasal clefts with or without harelip arise from incomplete coalescence of the middle and lateral frontal processes. In the same way is explained also (Madelung, Angerer, Kindler) the remaining open of a nostril on the side, which is sometimes combined with vertical fissure of the upper or lower eyelid (coloboma). Congenital atresia of the nares and entire absence of the nose are very rare. Trendelenburg mentions a case observed by Maisonneuve of a nearly normally developed female child seven months old whose nose was absent. In its place there was a level skin surface in which, instead of

Fig. 98.—Oblique facial cleft.

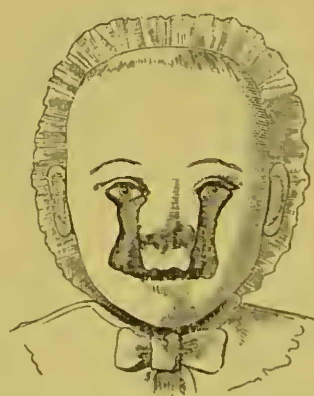


Fig. 99.—Double lateral facial cleft with macrostoma.

the nares, were two little openings scarcely a millimetre in diameter and three centimetres apart. Landow observed absence of one (the left) half of the nose.

If union does not take place between the lateral frontal process and the superior maxillary process (see Fig. 92, page 184), an oblique facial cleft results, which corresponds to the naso-orbital furrow. It usually begins at the free border of the upper lip or in the corner

of the mouth and terminates in the region of the lower eyelid or extends over the fronto-temporal region as far as the hair border (Fig. 98, after Hasselmann). In rare cases it is double. The case observed by Guersant (see Fig. 99) is to be regarded, no doubt, as one of double, very broad, oblique facial cleft. It is sometimes combined with enlargement of the oval aperture (macrostoma) (see Fig. 99)—that is, with transverse cleft of the cheek. The oblique facial cleft usually involves only the soft parts; sometimes, however, the bones of the face participate, so that the upper jaw and the hard and soft palate may be separated.

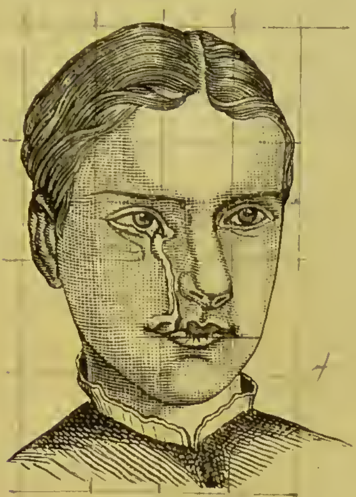


Fig. 100.—Congenital cicatrization of an oblique facial cleft (Kraske).

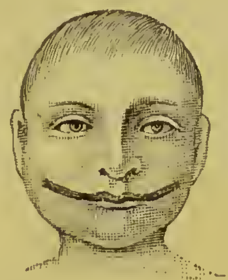


Fig. 101.—Congenital fissure of the cheek (macrostoma) in a male child two months old which was cured by freshening and suturing the edges.

Cicatrices are sometimes found in the naso-orbital furrow, caused by retarded intra-uterine coalescence of an oblique facial cleft, with or without fissure of the upper lip and lower eyelid (see Fig. 100). The complete coalescence of both eyelids and absence of the upper lids is a very rare malformation in the region of the fœtal naso-orbital furrow between the lateral frontal process and the superior maxillary process.

If coalescence of the mandibular arch and the superior maxillary process (see Fig. 92, page 184) does not take place, a transverse cleft of the face or cheek results, which may be unilateral or bilateral (see Figs. 99, 101). Transverse facial clefts usually begin at the corner of the mouth—that is, the oval aperture is enlarged (macrostoma). The extent of the cleft varies greatly. In extreme cases it reaches as far as the last molar, or even to the outer ear, and the retention of food in the mouth, and consequently nutrition, are seriously interfered with. Malformation in the region of the mandibular arch is often combined with deformities of the ear and with auricular appendages, or with oblique facial cleft, harelip, or rudimentary development of the lower jaw.

The above-mentioned auricular appendages are pieces of skin the size of a hemp seed or a cherry stone, or larger, which usually have a nucleus of cartilage, and are found especially in front of the ear in the region of the tragus

or on the cheek, very rarely behind the ear. They may be explained as an overproduction of tissue. Analogous formations are found on the neck at the border of the sterno-mastoid muscle, where congenital fistulæ of the neck, resulting from incomplete closure of the branchial clefts, usually have their external opening.

The opposite of macrostoma, an abnormally small oral aperture (microstoma), arises from too complete coalescence of the superior maxillary processes with the first branchial arch, and is usually accompanied by smallness of the lower jaw.

Fissures of the lower lip, resulting from incomplete coalescence of the halves of the first branchial arch, which are usually situated in the median line, are, according to Trendelenburg, extremely rare. The cleft affects either the lower lip only, or the lower jaw also and the tongue. Thorndike observed a complete cleft of the soft parts and the lower jaw reaching nearly to the hyoid bone. The tip of the tongue which had no cleft was attached near the hyoid bone. Wölfler saw a case of median cleft of the lower jaw, while the lower lip showed in the middle line a cicatrix with irregular distortion of the vermilion border. Another case was that of a median cleft of the lower lip, the lower jaw, and the tongue, in all of which the edges were united by scar tissue.

Trendelenburg mentions an observation by Engel of too complete a coalescence in the region of the first branchial arch—that is, of a congenital adhesion of the tongue to the floor of the mouth. The tongue was also attached to the floor of the mouth in the case of median cleft of the lower jaw which was seen by Wölfler.

Of other malformations in the region of the first branchial arch, fistulæ of the lower lip should be mentioned, which have been described more in detail by Demarquay, Rose, Fritzsche, Madelung, and others. Two dimples are found, usually placed symmetrically, near the middle line in the vermilion part of the lower lip, each of which forms the entrance to a blind fistula from one to three centimetres long, which secretes fluid resembling saliva. These fistulæ of the lower lip are malformations from arrested development which occur, according to Trendelenburg, only in connection with harelip and cleft palate. The hereditary occurrence of the same is striking. Smith and Israel saw also a unilateral fistula near the red portion of the lip, which may be regarded as a rudimentary second oral aperture, since a duplicature of the involved half of the jaw was suggested by a bony prominence.

Among other malformations in the region of the first branchial arch may be added malformations of the ear and in its neighbourhood, especially fistulæ in front of or behind the ear, on the lobe of the ear, and on the concha; increase or diminution in the size of the ear even to complete absence of the auricle; and finally closure or absence of the external auditory canal. The rudimentary development of the ear is often combined with defective

formation of the lower jaw. In connection with unilateral abnormal development of the ear and the lower jaw there usually exists asymmetry of the face. Auricular appendages on the ear and in its neighbourhood have already been mentioned (page 189).

Lastly may be mentioned among malformations in this region the existence of two rudimentary lower jaws (epignathus and polygnathus) and congenital absence of the entire tongue which was observed, according to Trendelenburg, by Jussieu and Spiller. W. Meyer has tabulated twenty-three cases of malformation in the region of the first branchial cleft and the first branchial arch (Archiv für klinische Chirurgie, Bd. xxix).

Unilateral congenital hypertrophy of the soft parts and bones of the face is very rare. It is almost always combined with accumulations of pigment in the skin and excessive development of the sebaceous and sweat glands.

Treatment of Congenital Malformations of the Face.—We consider here mainly the operative treatment of clefts of the lip and palate—that is, simple harelip and harelip in combination with cleft of the jaw and palate. Other fissure formations are treated upon essentially the same principles. In some of the above-mentioned malformations, treatment is in part unnecessary and in part impossible.

Operation for Harelip.—The treatment of harelip consists in carefully freshening the margins of the cleft and bringing them into close apposition by means of sutures.

When should the operation for harelip be undertaken? In answering this question one must make a distinction between clefts of the lip and those of the jaw and the palate. Many surgeons operate upon harelip as early as possible—that is, for example, in the first two weeks—because they think that the nutrition of such children is seriously interfered with. Such is not the case. Children with cleft of the lip which is not too wide and is unaccompanied by cleft of the jaw can take the breast if the nipple is well developed, and children with cleft of the lip and palate can drink from the bottle if only the India-rubber stopper has sufficient length and width and not too small an opening. Such children can not take the breast, it is true; they must be nourished with the bottle. König and other surgeons have obtained excellent results from early operation upon harelip, performing it in the first two weeks. Of seventy children operated upon before the end of the second week, König lost only one, who died of erysipelas. Trendelenburg strongly recommends later operation upon harelip, when the children are stronger and are from three to six months old. I should, in general, concur in his opinion. The condition of the child's strength is, of course, of great importance. The better the child's state of nutrition the earlier can the operation be performed.

The operation for cleft of both jaw and palate is not usually undertaken till from the fifth or sixth to the eighth year, because not till then do the children have the intelligence which is necessary in connection with the after-treatment. Julius Wolff has recently, however, operated upon these cases in the first year with very good results.

Simple harelip is operated upon without an anæsthetic after the arms of the child have been bound to its side with a broad mull bandage. The best way is for an assistant sitting in a chair to hold the child in a perpendicular position, grasping the head from behind in the region of the malar bones. One guards against hæmorrhage during the freshening of the cleft margins by passing a temporary suture around the coronary artery in the neighbourhood of the corner of the mouth, or by compression with small artery clamps, or by the hands of an assistant. The cleft is then freshened in its entire extent, according to one of the methods given below, and this is done somewhat obliquely, in order to secure broader wound surfaces—that is, one removes somewhat less tissue from the mucous membrane than from the outer skin. The paring is accomplished by piercing the margin of the cleft with a two-edged, lance-shaped knife, or a small, sharp-pointed scalpel, or with scissors. The two borders of the lip should then be completely detached with scissors from the jaw, in order that the edges of the wound may be sufficiently movable. After freshening the cleft of the lip and detaching it from the jaw, an exact suture is applied with small needles and fine aseptic silk; I always use small Hagedorn needles for the purpose. I use interrupted sutures of fine aseptic silk which has been treated with carbolic acid or bichloride, and then sometimes apply a continuous catgut suture in the manner that I have described (see Principles of Surgery, page 107). The interrupted sutures should take the form of deep tension sutures at some distance from the margins, while exact coaptation is accomplished by the continuous catgut suture. The mucous membrane should not be included in the suture, as it then comes to lie in the cleft of the wound. Lead-plate tension sutures (see Principles of Surgery, page 108) are usually unnecessary, but they are sometimes very serviceable. The figure-of-eight suture (see Principles of Surgery, page 109) has very properly gone out of use. In order to keep the nostrils, which are often much contracted after the operation, sufficiently open for respiration, thick-walled and not too short India-rubber tubes may be inserted.

What method of freshening is to be recommended? The choice of the method depends in part upon the nature and degree of the harelip. One should take care, above all, that after the operation no disfiguring

notch remains in the margin of the lip. The simple linear freshening of the cleft is therefore usually insufficient.

I mention the following methods of freshening, and take into consideration, to begin with, only single harelip:

1. Graefe's method (Fig. 102). After freshening the cleft by a curved incision, sutures are inserted in such a way that the curve becomes a straight line, and the line of union in the vermilion border projects downward. This method is adapted only to incomplete harelip or slight notches in the upper lip.

Fig. 102 *a*. Fig. 102 *b*.

Graefe's method of freshening and suture.

2. Nélaton's method (Fig. 103). This is likewise suited only for incomplete harelip or slight notches in the upper lip. The border of the cleft is detached by a curved incision and drawn downward as far as possible. The defect thus formed is closed, so as to form a vertical line of suture.

3. Method of J. Wolff (see Langenbeck's operation, Fig. 113, page 200). This is likewise suited especially for incomplete harelip which does not extend into the nose.

4. Malgaigne's method (Fig. 104). A pedunculated flap is fashioned from the red portion of the lip on each side, and both flaps are

Fig. 103 *a*. Fig. 103 *b*. Fig. 103 *c*.

Nélaton's method of freshening and suture.

allowed to fall downward. The two flaps and the rest of the defect are then united in a vertical line, so that a slight prominence results (see Fig. 104 *b* and *c*).

5. Method of Geraldès (see Fig. 105). The freshening is apparent

from Fig. 105. From the outer margin of the cleft a lower flap is formed out of the red portion of the lip and an upper one out of the

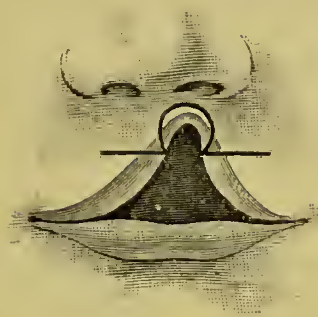


Fig. 104 *a.*

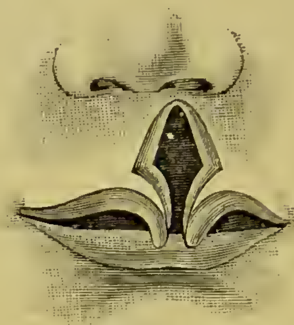


Fig. 104 *b.*

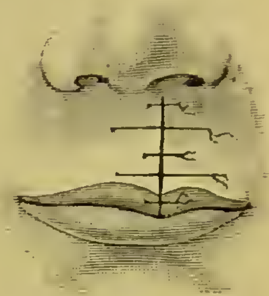


Fig. 104 *c.*

Malgaigne's method of freshening and suture.

inner margin, and they are then united, as shown in Fig. 105 *c.* This is a very serviceable method, which I can thoroughly recommend.

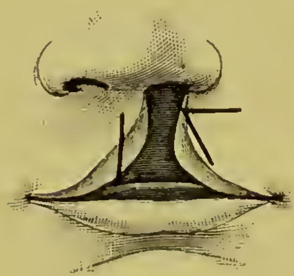


Fig. 105 *a.*

Fig. 105 *b.*

Fig. 105 *c.*

Geraldès's method of freshening and suture.

6. Mirault's method (see Fig. 106). This is also a good method, and is the one most frequently employed. The freshening is as repre-

Fig. 106 *a.*

Fig. 106 *b.*

Fig. 106 *c.*

Mirault's method of freshening and suture.

sented in Fig. 106 *a.* A flap is formed preferably on the outer side of the cleft. The flap must not be too small, but should include about

the lower third of the upper lip. The opposite margin of the cleft is freshened, so as to form a corresponding angle (Fig. 106 *b*). The sutures are inserted in such a way that the flap forms the lower margin of the lip (Fig. 106 *c*).

The methods of Mirault and Malgaigne are the most frequently used. They have been variously modified, especially by Simon, König, Hagedorn, Genzmer, and others.

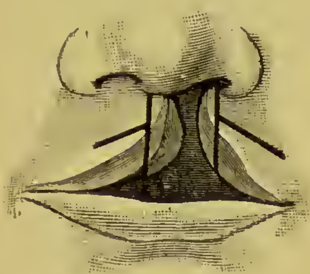


Fig. 107 *a*.

Fig. 107 *b*.

Fig. 107 *c*.

König's method of freshening and suture.

König cuts away the edges of the cleft completely (Fig. 107), and a flap is then formed on each side by means of a horizontal incision, parallel to the free margin of the lip. In suturing them, the two flaps are tilted somewhat downward.

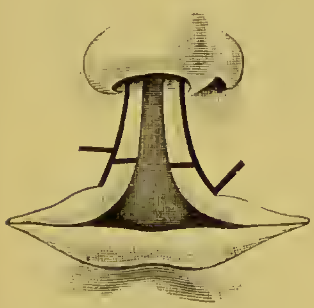


Fig. 108 *a*.

Fig. 108 *b*.

Fig. 108 *c*.

Hagedorn's method of freshening and suture.

Hagedorn uses a very serviceable method, as represented in Fig. 108.

Genzmer fashions a smaller flap on the inner margin of the cleft, and a larger one on the outer margin, and then unites them in such a way that the smaller flap comes to lie below. I can, from my own experience, warmly recommend this method, which I also devised independently.

In all cases of complete cleft of the lip which are wide and extend

up into the nose one must, as has been said, detach the portion of lip fixed to the upper jaw, especially on the outer, less frequently or less extensively on the inner margin of the cleft, in order to make the borders of the cleft more movable and to lessen the tension after suture. I detach the margins of the cleft from the upper jaw in every case. Relaxation incisions—e. g., along the ala nasi, after Dieffenbach (see Fig. 109), or horizontally beneath the nose with or without a curved incision around one or both alæ nasi (see Fig. 110)—are scarcely ever necessary.

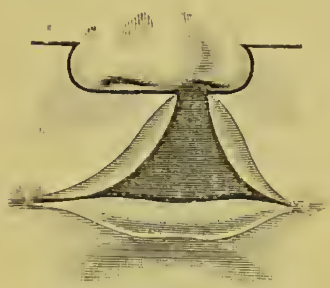


Fig. 109.—Liberating incisions about the alæ nasi (Dieffenbach).

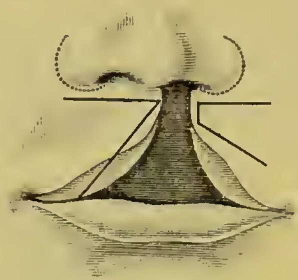


Fig. 110.—Straight liberating incisions beneath the nose with or without a curved incision around one or both alæ nasi.

Special measures are often requisite in case of an obliquely situated or prominent intermaxillary bone. This is often a serious impediment to the operation. We are speaking at present only of single harelip. When the prominence of the intermaxillary bone is marked, it may be bent back with a forceps, or it may be detached from the alveolar process by means of a chisel and forced back. The protruding bone has also been removed entirely with a small chisel. The first incisor on that side is then lost. All these operative measures on the intermaxillary bone are attended with much loss of blood, and they must there-

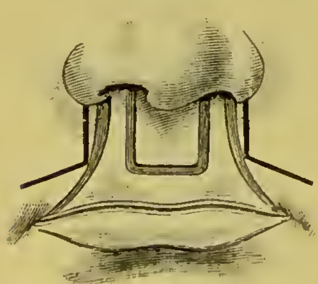


Fig. 111 *a*.

Fig. 111 *b*.

Fig. 111 *c*.

Operation for double harelip.

fore not be undertaken too early in the case of a delicate child (see also page 197). The hæmorrhage should be arrested as far as possible by compression from time to time.

The operation for double harelip, when there is no prominence of the intermaxillary bone, is to be performed in essentially the same

manner as has been described for single harelip—that is, all the borders are freshened. The best way is, generally speaking, to form on each side a rather broad Mirault's flap (see Fig. 111 *a* and *b*) and then trim off the tips of the same so as to form right angles. The flaps are brought together below the intermediate portion to form the free margin of the lip. The subsequent suturing of the flaps and the borders of the clefts must be very carefully attended to (Fig. 111 *c*). Incomplete double harelips also, which do not extend up into the nose, are best closed in this way. If the intermediate portion of the lip is very small, it is often a good plan to perform the operation on only one side at first, and then after a few weeks to undertake it on the other side.

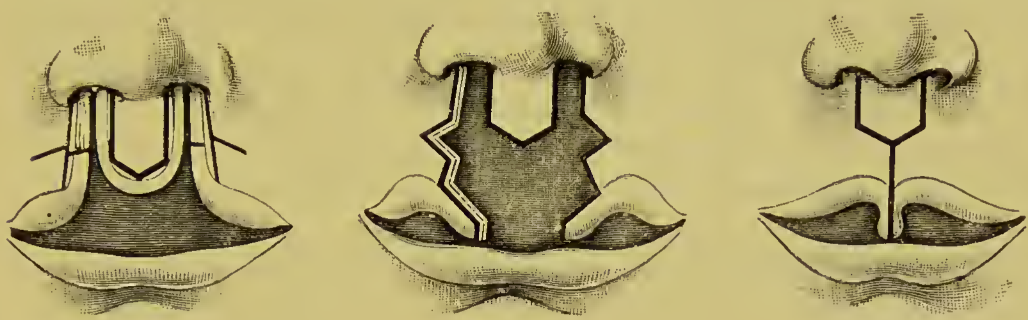


Fig. 112 *a*. Fig. 112 *b*. Fig. 112 *c*.

Hagedorn's operation for double harelip: *a*, method of freshening; *b*, after freshening; *c*, after suture.

Hagedorn's method is strongly to be recommended, which is easily understood from Fig. 112.

If double harelip is complicated with prominence of the intermaxillary bone in the form of a snout (see Fig. 95, page 186), various plans have been adopted for correcting the resulting deformity. The following methods deserve special mention:

1. Removal of the intermaxillary bone is the simplest method, and, as recent investigations have shown, it answers the purpose extremely well (see page 198).

2. The gradual forcing back of the intermaxillary bone by the operation for harelip—e. g., by forming very movable flaps, by means of curved incisions about the alæ nasi, after Simon—or by pressure with bandages, or India-rubber, or strips of adhesive plaster with India-rubber inserted, etc., is not to be recommended.

3. Forcing back the intermaxillary bone by operative interference —e. g., by breaking it away from the vomer, or by fracture of the latter (Gensoul), or by resecting a wedge-shaped piece from the vomer, and the cartilaginous nasal septum close behind the intermaxillary bone by means of bone-cutting forceps, and then crowding it backward

(Blandin). In carrying out this method, hæmorrhage may result from injury to the naso-palatine arteries, which it is difficult to arrest by compression, cauterization, or packing, and usually bony union does not take place, but the intermaxillary bone lies movable, as a rule, in the alveolar cleft. This movable connection is very disadvantageous in eating, and, even in case bony union follows, the vomer is likewise movable.

Bardeleben's method of subperiosteal division of the vomer and nasal septum is better than Blandin's. A longitudinal incision is made along the lower border of the vomer, beginning close behind the intermaxillary bone. The periosteum and the mucous membrane are detached with a small elevator on both sides of the vomer, and the bone is divided perpendicularly with bone-cutting forceps for about one or two centimetres in an upward direction, and the intermaxillary bone is then finally crowded back against the vomer. The operation is attended with comparatively little loss of blood, because the naso-palatine arteries are pushed aside uninjured with the periosteum. One can then undertake the operation for the harelip immediately at the same sitting, as the replaced intermaxillary bone is best held back in this way. The cleft in the alveolar arch is sometimes so narrow that the projecting intermaxillary bone can not be replaced. Its removal is then necessary.

This removal of the projecting intermaxillary bone is frequently resorted to, especially in England, and Trendelenburg is quite right in saying that if the results of removal and reposition of the bone are judged impartially, the difference is not great. Trendelenburg also has as yet seen no case in which the condition, some years after reposition of the intermaxillary bone, fully answered the expectations that had been entertained. According to Partsch, who has collected thirty-one cases of reposition of the bone, there was not one in which it could be used in eating, owing to its mobility and the position of the teeth. In the cases operated upon by Bruns, also, the replaced bone never united firmly (E. Müller). On the other hand, Volkmann, Braun, Gotthelf, Partsch, and Eigenbrodt have shown that after removal of the intermaxillary bone the teeth of the upper and lower jaws fit well together, and the disfigurement is not very great. It may be, therefore, that in Germany also removal of the projecting intermaxillary bone will become more customary in the future than it has been. The defect in the bone may be filled in with a plate containing the missing incisors. In milder cases reposition of the bone by Bardeleben's method will still continue to be performed.

The After-treatment of Harelip Operations must receive great attention. A dressing is not necessary. If the operation has been performed aseptically

and the child has received good care, the wound always heals by primary union. The child is fed with a spoon, or may be allowed to suck from a bottle with a soft India-rubber stopper. The greatest attention must be paid to the quality of the milk and to the most scrupulous cleanliness of the bottle and the stopper. The apparatus devised by Soxhlet is the best for this purpose.

Along the suture-line, which remains fully uncovered, crusts form in the next few days, which should be left entirely alone until the removal of the sutures on the third, fourth, or fifth day. Care must be taken that the nostrils, which are often very much contracted, do not become obstructed by dried blood or mucus, as suffocation may easily ensue from this cause. This danger must be strongly impressed upon the attendants. It is best avoided by inserting thick-walled and not too short India-rubber tubes into the lower meatus, as has already been stated. During the after-treatment everything should be avoided which causes tension on the wound or makes the child cry.

The first sutures are removed on the third or fourth day. Some are allowed to remain till the fifth day. It is not necessary to remove the fine catgut sutures. The outer loops fall away of themselves, or may be picked off with small forceps after the absorption of the inner loops. All pulling must be avoided in removing the sutures, The head of the child should be firmly held, and the scissors pushed under the loop without drawing upon the thread. The crusts of blood clot are carefully removed at the same time, and the suture line may then be covered with a little boric ointment to prevent the further formation of crusts. Dressings for relieving tension, and the use of other special apparatus after the removal of the sutures, are unnecessary. If, after their removal, the wound should threaten to open again, in consequence of suppuration or injudicious after-treatment of any kind, this should be prevented by secondary suture, and if it actually does open it must be closed again by suture while its margins are still sufficiently fresh. The secondary sutures must, of course, be inserted farther from the edge of the wound than the primary. Generally speaking, the experience with secondary suture is not very favourable, as healing often fails to take place after all. In such cases one must wait at least from six to eight weeks, and it is better to wait from four to six or even nine months, until the cicatricial borders of the cleft have again become soft and extensible, before performing a second operation.

Any secondary operations with a view to improving the cosmetic result should not be undertaken too early, often not until the age of puberty. These are performed most commonly for a defective union at the nostril, too large a nostril, and for a notch or unsymmetrical contour of the vermilion border. In case of insufficient union at the nostril or too large a nostril, the secondary operation consists in freshening the defect, detaching the ala nasi from the underlying parts, and suture. Notches on the vermilion border can be easily remedied, like incomplete harelip, by means of a curved incision parallel to the border of the lip and by suture in a vertical direction, as Nélaton has recommended (see page 193, Fig. 103). Wolff has secured excellent results in these cases by means of Langenbeck's operation. By this method (see Fig. 113) almost the entire length of the border of the lip

nearly to the corners of the mouth is separated from the lip and sutured in such a way that a part of the detached margin is brought together as a prominence in the middle line, and here united longitudinally by sutures. The line of suture is finally ⊥ shaped (Fig. 113 *c*). The projecting piece which is at first rather malformed finally retracts, so that it comes to resemble the normal prominence at this point below the median vertical

Fig. 113 *a*. Fig. 113 *b*. Fig. 113 *c*.

Operation for hare-lip by separation or displacement of the vermilion border (Langenbeck and Wolff).

groove. One can operate in this way also in case of incomplete harelip which does not extend up into the nose. If the border of the lip is somewhat higher on one side, partial excisions are often sufficient.

The mortality attending operation for harelip is small, if the operation is performed in accordance with aseptic rules and by an experienced surgeon, and the children are properly cared for afterward. In the first two weeks after the operation the mortality amounts, according to Fritzsche, to about five per cent, and even this estimate is too high for many surgeons. The mortality from the affection or from the operation increases, generally speaking, with the degree of the malformation. A large percentage of children with harelip, after passing through the operation successfully, die later at home, under unfavourable hygienic surroundings, from disturbances of digestion, marasmus, and broncho-pneumonia, resulting from insufficient care and nutrition. The total mortality of all children operated upon during their first year is therefore surprisingly high. According to Trendelenburg it reaches 41·6 per cent. Herrmann's statistics show that it amounts in the first months to 52·4 per cent, and then gradually falls in the later months to 39·4, 32·4, and 20 per cent. Gotthelf secured similar statistical results.

Fig. 114.—Oblique facial cleft cured by several operations.

The other above-mentioned clefts of the face are treated by freshening and careful suture, upon essentially the same principles as hare-

lip. That one can in several sittings secure excellent results in treating extensive clefts of the face is proved by Hasselmann's case represented above in Fig. 98, page 188, which finally, after several operations, gave the result shown in Fig. 114.

For the operations for clefts of the jaw and the palate, see Uranoplasty and Staphylorrhaphy, § 63.

§ 26. **Injuries of the Soft Parts of the Face.**—Wounds, especially incised wounds, occur very frequently in all parts of the face, particularly from rapiers, knives, daggers, fragments of glass, etc. Dangerous hæmorrhages may arise from injury of the facial or temporal artery, and especially the deep temporal artery. (For injury of the temporal artery see also pages 5–9.) Aneurisms not infrequently result from injury of the above-named arteries. Of other injuries in the face, those of the eyes, the nasal duct with subsequent lachrymal fistula, the facial nerve, Steno's duct (see parotid), complete or incomplete severing of the tip of the nose or of the ear, etc., are of special importance. The underlying bone is not infrequently injured, and in some cases the nasal cavity, the frontal sinus, or the antrum of Highmore is opened.

In punctured wounds the important thing is to know the depth of the injury; whether a deep-lying artery—e. g., the deep temporal artery—is injured; whether the antrum of Highmore is opened; and whether the cranial cavity has been entered or even the brain itself injured by stabs—e. g., through the nose and cribriform plate or the orbit. The point of the instrument that inflicts the injury is not infrequently broken off in the bone, in the antrum of Highmore, in the nose, or in the orbit, and either heals up here without reaction or leads to cellulitis, or even death in case of penetrating injuries of the skull, for example, from meningitis or abscess of the brain. Foreign bodies that heal in place often wander about and appear again in other parts of the body.

Regarding wounds caused by the bites of different animals and poisoned wounds, the reader is referred to Principles of Surgery, §§ 76–82.

Lacerated and contused wounds have also been sufficiently discussed in Principles of Surgery, § 87, as well as subcutaneous contusions and hæmatomata without any external wound (see § 92). Subcutaneous hæmorrhages in connection with contusions occur particularly in those parts of the face where there is loose cellular tissue, as on the eyelids or the lips. They are altogether free from danger.

Gunshot wounds of the face are observed chiefly, in time of peace, among suicides from shooting into the mouth. In such cases the ball very often passes through the hard palate into the nasal cavity, and the

exit opening lies at the root of the nose, as the person bends his head too far back at the moment of the discharge. In other cases death ensues immediately in consequence of hæmorrhage or of injury to the brain. Extensive laceration of the soft parts and shattering of the bones of the face and cranium also attend injuries from pistols loaded with water. The most severe gunshot injuries of the face are seen in war from the use of bombs and heavy ordnance in general. Spent balls not infrequently remain in the antrum of Highmore, or in the nasal cavity, or occasion merely contusions of the soft parts. A reserve officer experienced a rare injury from shooting in 1870, who, as Trendelenburg mentions, was shot transversely through the cheeks and the mouth without injury to the bones, being struck just as he was shouting "Hurrah!"

The burning of the skin, especially in case of shots fired from a very short distance, is worthy of notice. In consequence of the healing in of grains of powder, the skin of the face often remains of a permanent grayish-black colour. Much the same is true when small shot is used, by which, moreover, very extensive destruction may be caused if fired from a short distance.

See also the discussion of gunshot wounds in Principles of Surgery, § 124.

Cephalic Tetanus.—After injuries in the region supplied by one of the twelve cranial nerves, so called, cephalic tetanus occasionally occurs—that is, tetanus which is mainly confined to the head. There is a tetanic contraction of the muscles of mastication, so-called trismus, which is usually combined with paralysis of the facial nerve and spasm of the pharyngeal muscles (Rose). On account of the spasm of the pharynx, analogous to that in hydrophobia, this tetanus has been called hydrophobic tetanus. Rose explains the paralysis of the facial nerve as arising from the incarceration of the swollen facial nerve in the Fallopian canal. According to Brunner, this paralysis of the facial nerve, in connection with cephalic tetanus, is based upon errors in observation. Brunner produced cephalic tetanus in rabbits and Guinea-pigs by means of inoculation with pure cultures of the tetanus bacillus, and found that there was no paralysis of the involved side of the face, but that the apparent asymmetry resembling that in facial paralysis was, on the contrary, conditioned upon tetanic contraction. When inoculations were made in the median line of the face, both sides were tetanic. If, in connection with unilateral inoculation, the facial nerve on that side was divided, facial paralysis then first made its appearance, the contracting muscles becoming relaxed. As P. Klemm has also stated, paralysis of the facial nerve is probably nevertheless present in a portion of the cases.

Cephalic tetanus is not always fatal. Of fourteen cases collected by Güterboek and Bernhardt, four recovered. Chronic cases, in which, according to the tabulation of Klemm, the affection may last from four to twelve weeks, are more likely to recover than acute cases. Of twenty-four patients

with cephalic tetanus, seven, according to Klemm, recovered, and of these seven cases six were chronic.

The treatment of wounds of the face conforms to general rules, and must be strictly aseptic in accordance with the methods described more in detail in Principles of Surgery (see § 88). The arrest of hæmorrhage by ligation of the arteries involved is only necessary when the facial and temporal arteries are injured. If the wound is sutured aseptically, and its edges brought into exact coaptation, silk or catgut being used, wounds of the face heal in a few days by primary union. Simple interrupted sutures with fine silk and a continuous catgut suture are the best. Sutures about the eyelids and the lips must be inserted with special care, in order that the contours of these parts may become as normal as possible again. If the orbit is opened through injury of the tarso-orbital fascia, drainage is accomplished, if necessary, by means of inserted catgut threads. If the facial nerve is injured, direct or indirect (paraneurotic), neurorrhaphy is performed (see Principles of Surgery, § 88). Completely detached portions of the nose and ear are more likely to unite again if sutured in place at once aseptically and if there is no suppuration. Berenger-Feraud has collected four cases of complete detachment of the auricle in which a complete reunion was obtained. In a case reported by Manni (1834) the injured person, as Trendelenburg mentions, had carried his detached ear several hours in his pocket before it was replaced, and still it healed in place. Flap wounds must be sutured so as not to produce traction in any way upon the nutritive pedicle.

In punctured wounds special attention should be paid to the presence of foreign bodies in the wound, and to the possible puncture of an artery, especially the deep temporal arteries which we have already mentioned on pages 5 and 9. When speaking of injuries of the skull we described sufficiently the treatment of punctured wounds penetrating into the cranial cavity—e. g., through the orbit or through the nasal cavity or the cribriform plate.

The treatment of lacerated and contused wounds, and contusions without wounds (hæmatomata), has been described in detail in Principles of Surgery, §§ 88, 92. For the treatment of gunshot wounds, the reader is likewise referred to Principles of Surgery, § 124; and for injuries from this cause to the brain and its adnexa, to §§ 15–20. The treatment of powder burns of the face is given on page 205. In gunshot injuries of the face one must be especially on his guard against secondary hæmorrhage from the branches of the facial, the internal maxillary, and the superficial and deep temporal arteries, especially at the time of suppuration after from the sixth to the tenth day. When

there is profuse hæmorrhage from the mouth or nose, it is often difficult to find its source, so that prompt ligation of the common or external carotid artery may be necessary. Ligation of the common carotid artery is simplest, but the brain is affected thereby. Ligation of the external carotid is, on the other hand, more difficult, but it leaves the brain unaffected (see Surgery of the Neck, Ligation of the Carotid Arteries). After the establishment of the circulation through the collateral vessels of the uninjured side, secondary hæmorrhage may ensue, so that ligation of the carotid may here also be necessary if one can not arrest the hæmorrhage by proximal and distal ligation of the injured vessel in the wound.

Ligation of the facial artery is performed at the anterior edge of the masseter muscle, where the artery passes over the border of the lower jaw. An incision is made parallel to the border of the masseter muscle.

The occipital artery is found by means of a vertical incision, which lies in a line drawn from the external occipital protuberance to the posterior border of the mastoid process.

For ligation of the superficial and deep temporal arteries, see page 9.

For a description of ligation of the common, the external, and the internal carotid arteries, see Surgery of the Neck, § 90.

Burns of the Face are most commonly caused by hot or boiling liquids, by caustics, direct contact with a flame, by the explosion of powder, illuminating gas, fire damp in mines, etc.. The first and mildest grade of burning is characterized by hyperæmia, the second by the formation of vesicles, and the third by eschar formation. The mildest burns arise from the influence of the sun's rays upon pedestrians, for example, after exhausting tramps in great heat (*erythema solare*). Deep burns of the face are observed especially among epileptics and the insane. Burns of the face are very varied. The eyes are usually protected from the direct influence of burns by the closing of the lids, so that usually the lashes and eyebrows only are burned, but severe conjunctivitis, ulcers of the cornea, and complete blindness result only too often from deep injury of the bulb.

The disfiguring cicatricial contractions which result from deep burns of the face are also of special interest. These may be, for example, on the eyelids (ectropium), the alæ nasi, the cheeks, or in the neighbourhood of the mouth, so that the latter may be diminished in size or prevented by cicatricial lockjaw from opening sufficiently. Extensive and thick cicatricial bands sometimes form between the neck and the region of the chin (Fig. 115), so that flexion of the head is seriously

interfered with, and the skin of the face, together with the mouth and the eyelids, may be drawn downward. (For a discussion of burns, sunstroke, and lightning-stroke, see also Principles of Surgery, § 90.)

The treatment of burns of the face conforms to the principles given more in detail in Principles of Surgery, § 90. Disfiguring cicatricial contractions are to be prevented as far as possible, especially by Thiersch's skin-grafting (see Principles of Surgery, § 42). In case they already exist, they are to be overcome by plastic operations (see §§ 29–33, Plastic Operations upon the Face). B. Credé has shown in one case what excellent results may be obtained by plastic operations and skin-grafting after burns of the face. In case of powder burns, the grains that have been forced into the skin may be removed by curetting the skin with a sharp spoon to prevent the disfiguring pigmentation of the cutis which would otherwise be permanent. Hebra recommends applying compresses wet with 1-to-100 bichloride, so as to make the skin raw superficially, and thus make it possible to scrape off the softened cutis with the powder grains that are contained in it.

Fig. 115.—Cicatrices following a burn from boiling water in a boy five years of age.

For sunburns, compresses wet in liquor plumbi subacetatis dilutus and ice are applied, and the face is smeared with unguentum diachylon or vaseline, and afterward powdered with starch or oxide of zinc with starch (1 to 5–10). As precautionary measures against such burns from the sun's rays during mountain tramps, the use of sun umbrellas, the wearing of veils, and the like, are to be recommended. People with a delicate skin should besmear the face lightly when making long trips with vaseline, hart's suet, lard, or unguentum diachylon, and then powder it with starch.

For a description of frostbites and their treatment the reader is referred to Principles of Surgery, § 91. In the action of cold upon the face, the nose and the ears are especially endangered. The usual result is simply red ears and a red nose in consequence of paralysis of the vessels. This makes itself especially noticeable in a warm room, or after taking anything alcoholic. Chilblains and gangrene from frostbite are very rare in the face.

The treatment of frostbites has been given in detail in Principles

of Surgery, § 91. Riedinger recommended the injection of ergotin as a remedy for redness of the nose caused by cold. I have repeatedly secured very good results by means of punctate cauterization with a galvano-caustic needle.

§ 27. **Surgical Diseases of the Face.**—Of inflammatory processes in the face, I mention first the acute inflammation of the sebaceous glands and hair follicles, the so-called furuncle, which most commonly results from the entrance of the *Staphylococcus pyogenes aureus* and *albus* into the pores of the skin, and is sometimes combined with marked inflammatory redness and swelling (see particulars in Principles of Surgery, § 93). Its favourite location in the face is the upper lip and the septum of the nose.

In case of prompt incision and expulsion or removal of the necrotic slough, rapid healing follows. The development of a furuncle may often be prevented by immediately opening the small acne pustule at the beginning and disinfecting it with 1-to-1,000 bichloride.

By carbuncle is understood a number of furuncles situated more or less closely together. The best treatment here also consists in speedy incision, as described in detail in Principles of Surgery, § 93.

There also occurs in the face, and especially on the lip, a malignant form of furuncle and carbuncle, which is due to septic infection and may, under the form of a septic phlegmon, terminate fatally on the second or third day in the worst cases, or later, after from eight or ten days to a fortnight. Death ensues from general sepsis, from suppurative venous thrombosis, reaching into the internal jugular and ophthalmic veins, with subsequent thrombosis of the sinuses and suppurative meningitis. If recovery follows, it is usually attended with extensive suppuration and gangrene. This malignant septic form sometimes begins as an apparently non-malignant small furuncle, but marked swelling then sets in with high fever and severe pain. The swelling spreads rapidly and soon involves, as a rule, the neck. In other cases there is from the first a carbuncle, which grows into a rapidly progressive septic phlegmon. The mucous membrane also may be the starting point of the inflammation. An epidemic of cases has sometimes been observed. We have to do in the main, as has been said, with a severe septic infection or septic phlegmon. This malignant, septic form of furuncle or carbuncle has nothing to do with anthrax and glanders, which are well-characterized affections.

The treatment consists in speedy and free incisions, and one may often prevent the further spread of the process by scraping out the focus of infection at the beginning, or by the use of the Paquelin cautery. Unfortunately, the surgeon is often called too late, and the

fatal termination can then no longer be averted by incisions, however numerous.

Malignant Pustule (see Principles of Surgery, § 77) not infrequently occurs on the face of persons who have to do with animals affected with anthrax, and is conditioned upon the presence of a specific bacillus (see Principles of Surgery, page 381, Figs. 279–286). It can be transmitted, as is well known, to the skin of man by means of insects—flies (Huber). Anthrax begins at the place of inoculation on the face, after an incubation of from three to six days, by the formation of a burning, itching, red nodule with a reddish or bluish vesicle which soon bursts and dries into a scab. The surrounding skin then usually becomes swollen, and more vesicles are formed. The primary nodule at the point of infection is usually from the size of a pea to that of a nut. The induration and œdematous swelling usually spread very rapidly from the primary focus, and the neighbouring lymphatic glands become swollen. From forty-eight to sixty hours after the beginning of the local symptoms the manifestations of a general infection appear (high fever, delirium, prostration, diarrhœa, and severe, vague pains). Death usually ensues after from five to eight days. If the termination is favourable, the eschar is sometimes cast off by suppuration.

The prognosis of anthrax of the skin is more favourable, because it here remains local longer and is accessible to an energetic treatment. Lengyel and Koranyi, in consequence of their energetic local treatment, lost only thirteen patients out of one hundred and forty-two who were treated for anthrax of the outer skin. In anthrax caused by internal infection (intestines, lungs) recoveries are very rare.

The treatment of anthrax on the face, and on the outer coverings in general, consists in the earliest possible removal of the infected area by means of the knife, the thermo-cautery, or by cauterization with nitric acid. Subcutaneous injections of bichloride in and around the site of infection are also to be recommended, as this is, according to R. Koch, the most efficacious antidote for the anthrax bacilli, which are killed by a solution of 1 to 300,000. Davaine recommends subcutaneous injections of diluted tincture of iodine (one part to two of water).

Glanders is an infectious microbic disease which occurs primarily chiefly among horses and donkeys, and which can be transmitted to man and all domestic animals, with the exception of cattle. The characteristic glanders bacillus (see Principles of Surgery, § 78) was discovered by Löffler and Schütz. In man, glanders usually occurs on the conjunctiva, less often on the nasal mucous membrane, and it appears also as glanders of the skin after slight injuries to the face and hands.

Glanders has, in man as in animals, either an acute or a chronic course, and the characteristic nodules and ulcers are formed here also at the place of infection—e. g., in the face (Fig. 116)—and metastatic glanders nodules occur in the internal organs.

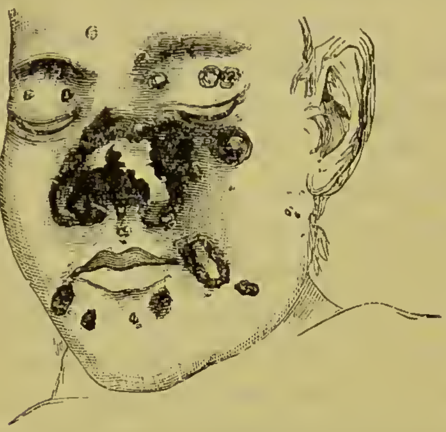


FIG. 116.—Acute infection with glanders; ulceration of the skin of the face occurring within eight days (Birch-Hirschfeld).

In glanders of the face, and of the integument in general, the same prompt and energetic local treatment is necessary as was advised above for anthrax. For other particulars the reader is referred to Principles of Surgery, § 78, where glanders both of animals and man has been described more in detail.

Noma.—By noma, or cancrum oris, is understood a progressive gangrene, originating in the mucous membrane of the cheeks, which rapidly involves the entire thickness of the cheek. The termination is either fatal, or in case of recovery the latter is attended with more or less extensive destruction in the region of the cheek or about the mouth (see Fig. 117, after W. Busch).

Noma is really a hospital gangrene which develops in connection with ulcerative stomatitis. It is most frequent among reduced, anæmic children with measles or scarlet fever, being less commonly observed among infants and adults. The process always begins in the mucous membrane of the cheek, and almost always near the corner of the mouth. In connection with erosions or ulcers that develop here, an infiltration arises with œdematous swelling of the face, which passes rapidly into gangrene. The gangrene usually shows itself on the outer skin by the appearance of a livid spot. The course of the affection is very acute, as a rule, and the cheek may become perforated in three or four days after the appearance of the first symptoms in the mucous membrane. There may be a fatal termination from five to eight days after the commencement of the disease from septicæmia or collapse, or from hæmorrhages, especially from the facial artery; or, on the other hand, recovery may follow with sloughing away of the gangrenous parts. The gums, also the jaws, the tongue, and the hard and soft palate, may be attacked by the destructive process. The defects, which are often very considerable at first, grow smaller later, in con-

FIG. 117.—Noma following scarlet fever in a boy of four.

sequence of cicatricial contraction, and firm cicatricial bands are finally formed about the mouth, so that the lower and upper jaws are more or less firmly fixed to one another (cicatricial lockjaw, false anchylosis of the jaw).

Ranke had the opportunity of observing six cases of noma during a large epidemic of measles in Munich in the summer of 1887. Attempts to inoculate the disease by grafting small portions of the tissue beneath the skin of rabbits were unsuccessful. By microscopic examination there were found in the necrotic zone, on the border of the noma defect, great quantities of bacteria which were almost exclusively cocci, in part diplococci, and in part streptococci. There was observable, above all, a marked destruction of the nuclei of the white blood-corpuscles, as well as of the nuclei of the connective tissue and muscular fibres.

The treatment of noma is of an energetic local character, much the same as in hospital gangrene, and it should be undertaken as promptly as possible. The gangrenous focus is best destroyed by means of the galvano-cautery or thermo-cautery. The application of liquid or solid caustics (sulphuric acid, chloride of zinc, caustic potash, etc.) is less effectual. For the treatment of the resulting defects and cicatricial lockjaw see § 33, Plastic Operations upon the Face (Meloplasty).

By sycosis or mentagra is understood an inflammation of the hair follicles which is always, no doubt, of parasitic origin, and is usually caused by the tricophyton (Köbner). Sycosis takes the form of acne or ulcerative eczema of the hairy portions of the face, and heals with the formation of cicatrices and loss of the hair. Sycosis occurs only in men.

Sycosis may be very quickly cured if the hairs in the diseased area are extracted under an anæsthetic with a ciliar forceps and the ulcerating surface of skin scraped with a sharp spoon. After these areas are scraped they should be painted with glycerin or tincture of iodine, or cauterized with nitrate of silver. Ignipuncture is also very serviceable.

Acute or chronic eczema occurs frequently on the face. Vesicles or pustules are formed, which dry so as to form crusts. The skin in the neighbourhood of the vesicles is usually reddened. There is always more or less severe itching.

The treatment of eczema consists in the removal of the existing cause—nasal catarrh, conjunctivitis, otorrhœa, etc.—and in the application of exsiccant remedies. After removal of the crusts the diseased part of the skin is smeared with unguentum diachylon or vaseline and powdered with starch and oxide of zinc in the proportion of five or ten to one.

For eczema due to sunburn, see pages 204 and 205.

Facial Erysipelas occurs exclusively in connection with breaks in the continuity of the outer skin, or of the mucous membrane of the facial cavities, and is caused by the entrance of the streptococcus of erysipelas into the smaller lymph passages of the skin and subcutaneous cellular tissue. Erysipelas following operations has become rare, as it

can be surely prevented by strict asepsis. Idiopathic erysipelas of the face, without a break in the continuity of the skin, from "taking cold" does not exist.

For a more detailed description of erysipelas, the erysipelas coccus, etc., see Principles of Surgery, § 71. The following brief description will suffice here:

Erysipelas of the skin of the face very often spreads to the neighbouring mucous membrane of the facial cavities, or, on the other hand, an erysipelas starting from a wound, an erosion, or an ulcer of the mucous membrane may spread to the skin. In fact, the recurring or chronic facial erysipelas which was formerly regarded as idiopathic, arises most commonly from catarrhal ulcers of the naso-pharyngeal cavity which are often superficial. Erysipelas of the mucous membrane of the facial cavities may cause œdema of the glottis by spreading to the epiglottis and the larynx, so that tracheotomy may be necessary. It may also make its way to the lungs, and here occasion so-called "creeping pneumonia," which is characteristic of erysipelas of the mucous membrane of the air passages.

The phlegmonous and gangrenous forms of facial erysipelas are rare, and if suppuration or gangrene occurs, it is usually very circumscribed. The swelling in erysipelas is especially marked upon the lips and the eyelids, so that the latter are usually wholly closed.

The duration of facial erysipelas varies from hours or days to weeks, averaging from six or eight to ten days.

It is a fact of special interest that lupoid and syphilitic new-growths, with or without ulceration, and tumours, such as sarcoma and carcinoma, may wholly disappear by fatty disintegration if erysipelas passes over them (so-called curative erysipelas, *érysipèle salutaire* of the French). Erysipelas has therefore been inoculated into inoperable tumours in order to cause them to disappear by this means.

The prognosis of facial erysipelas is not bad, and yet one can never feel sure of a favourable termination. The average mortality from erysipelas is about eleven per cent. Erysipelas of the face sometimes leads to death from meningitis. After severe (pyæmic, septic) erysipelas, embolic processes are sometimes observed—e. g., in the brain, in other internal organs, and on the limbs. Gangrene may then result—e. g., of the foot, the leg, etc.

The treatment of facial erysipelas conforms to generally accepted rules, as described in Principles of Surgery, § 71. It ensues so often from affections of the nose that the naso-pharyngeal space should always be carefully examined, and any disease existing there given the proper treatment.

Lupus of the Face (see Fig. 118), like all lupus, is a primary tuberculosis of the skin. Less frequently it begins primarily in the mucous membrane of the facial cavities and spreads from here to the skin. One always finds in the lupoid foci the tubercle bacilli (Friedländer, Pfeiffer, Doutrelepont; see Principles of Surgery, §§ 83, 93). Lupus develops in the skin from the activity of tubercle bacilli in the normal pores of the skin, in wounds or in the slightest abrasions. Anatomically, very small nodules or tubercles are formed, and corresponding cutaneous ulcers arise from the breaking down of these tubercles. In conjunction with the nodules and ulcers, diffuse infiltration and hypertrophy of the tissues are frequently observed. The epithelium often grows into the subcutaneous cellular tissue in the form of irregular epithelial proliferations, so that, histologically, changes resembling carcinoma take place. This explains the fact, perhaps, that persons afflicted with lupus not infrequently develop epithelioma (see Fig. 119).

Fig. 118.—Lupus of the face (Esmarch).

Fig. 119.—Epithelioma of the right orbital region in a patient suffering from lupus (Esmarch).

From a clinical standpoint three forms are distinguished: lupus maculosus (or lupus exfoliativus), lupus exulcerans, and lupus hypertrophicus. In lupus exfoliativus, red or yellowish-brown spots are formed with a fissured or exfoliating epidermic covering. Ulcerative lupus (lupus exulcerans, or lupus vulgaris) may lead to extensive destruction of the skin and the neighbouring structures, especially on the nose, the cheeks, the lips, and the eyelids. The mucous membrane is usually affected secondarily, primary lupus of the mucous membrane being more rare. The bone usually remains intact, so that, generally speaking, defects of the bony part of the nose are mostly of a syphilitic nature, while those of the soft parts and of the cartilage of the nose

arise chiefly from lupus. The cartilaginous septum of the nose is destroyed particularly by lupus exulcerans.

The process very often progresses at the periphery of the lupus focus, while smooth, radiating cicatricial tissue forms in the centre. The nodular form of the affection is called lupus hypertrophicus. There are various transitions between the individual forms, and combined forms of the disease often occur. The course of lupus is very chronic. It generally begins at the age of puberty or later, and may continue till extreme old age. Those affected with lupus not infrequently die of tuberculosis of the internal organs or become, as has been said, the victims of epithelioma. The disfigurements of the nose, the cheek, and the eyelids are often very marked.

Treatment of Lupus.—In addition to the adoption of general strengthening measures (see § 83 Principles of Surgery), lupus should receive energetic local treatment, consisting preferably in excision of the affected area of skin, followed by a plastic operation if necessary (see §§ 29–33, Plastic Operations on the Face), or in destruction of the lupoid foci by the use of a sharp spoon, the thermo-cautery, or the galvano-cautery. In lupus erythematosus, punctate cauterization with the thermo-cautery or galvano-cautery is usually sufficient, while in lupus exulcerans and lupus hypertrophicus the diseased parts must be energetically removed beforehand with a sharp spoon. After use of the latter, and after arresting the hæmorrhage, one may, especially when large surfaces of the skin are diseased, either immediately or on the next day perform skin-grafting by Thiersch's method. I am confident that, as a result of such grafting, I have seen fewer recurrences. In case of lupus in the region of the nose it is often necessary to gain free access to the nasal cavity by dividing the nose in the median line as far up as the nasal bone, or still farther (see Surgery of the Nose). Cicatricial contractions or deep defects are remedied by plastic operations. As regards the treatment of lupus by the injection of tuberculin, cantharidic acid (Liebreich), and other medicinal remedies, see Principles of Surgery, pages 421 and 518. Thayer saw good results follow exposure for two minutes to direct sunlight by means of a lens, especially in suppurative lupus. Among other medicinal remedies, the worth of which I prize none too highly, chloride of zinc and pyrogallic acid have been employed locally.

Syphilis of the Face.—The primary syphilitic sore, syphilitic or hard chancre, is observed in various parts of the face, most frequently on the lips. Epithelioma, glanders, or anthrax may sometimes be confounded with chancre. The correct diagnosis can generally be easily reached, however, from the character of its course, from the history of

the patient, and from microscopic examination. The lardaceous appearance of the base, and the rapid development of the ulcer as compared with epithelioma, point to chancre. Anthrax and glanders are very characteristic diseases (see page 207, and Principles of Surgery, §§ 77, 78). They occur in persons who have to do, in consequence of their calling, with animals, hides, or carcasses infected with anthrax or glanders. Soft, non-syphilitic chancre is much less common in the face than the hard form. Phagedenic (gangrenous) chancre, which may lead to deep, gaping defects, is very rare.

The secondary manifestations of syphilis (see Principles of Surgery, § 84) are very common on the face. They consist partly of syphilitic eruptions of the skin, especially on the forehead, and of ulcers of the skin and mucous membrane combined often with necrosis of the underlying bone, as described in detail under Syphilis of the Skull (see pages 70–73). For syphilitic disease of the nasal cavity the reader is referred to Surgery of the Nose.

These secondary syphilitic ulcers also, which develop from circumscribed or more diffuse syphilitic infiltrations, and especially from gummata, have sometimes been confounded with epithelioma. In epithelioma the edge of the ulcer is hard and infiltrated, and not so strikingly circular or curved in form. The syphilitic nature of an ulcer is also made probable if it heals up when treated by inunction and the administration of iodide of potassium, together with proper local treatment (scraping with a sharp spoon, thermo-cautery). Syphilitic ulcers have sometimes, however, a strikingly malignant character, the destruction of the soft parts and the bone making steady progress, in spite of mercury and iodide of potassium, and leading to large defects on the lips, the eyelids, and especially on the nose. As a rule, we have here to do with cases which were not subjected at first to a sufficiently thorough general and local treatment.

Syphilis of the face, as elsewhere, should receive a proper constitutional as well as local treatment. The latter consists in scraping out the syphilitic ulcers, in the use of the thermo-cautery, in the application of caustics (caustic potash), etc. (see Principles of Surgery, § 84, and page 73 of this work, Syphilis of the Skull).

Tumours of the face in the region of the eyes, the cheeks, and the lips comprise many varieties. For a more detailed description of the different kinds, see also Principles of Surgery, §§ 125–130.

Of epithelial new-growths of the face, the carcinoma is by far the most common form (see Principles of Surgery, § 129).

Epithelioma of the face begins more frequently in the skin than in the mucous membrane. It has a preference for the places of transition from the

skin to the mucous membrane, on the lower lip, for example, and the eyelids. Epithelioma of the upper lip is extremely rare.

Epitheliomata of the skin of the face originate in the cells of the rete Malpighii, or in the sebaceous glands and hair follicles. There arises an infiltration of the corium, and later of the underlying tissue with epithelial cells, which, in the form of single groups or nests, lie in a partly old and partly newly formed connective-tissue stroma (cancerous stroma).

Fig. 120 *a*.

Fig. 120 *b*.

Fig. 120 *c*.

Types of epithelioma of the face.

The external appearance of an epithelioma of the face is varied. Circumscribed nodules are found most frequently, or more diffuse flat infiltrations and indurations, usually accompanied by the formation of ulcers, especially on the lower lip in men (see Fig. 120 *a*), or one finds papillary, branching growths (Fig. 120 *b*), or, finally, deep ulcers with solid, infiltrated margins and corresponding contraction of the surrounding tissue (Fig. 120 *c*).

From an anatomical and clinical standpoint we distinguish with Thiersch two forms of epithelioma, the superficial and the deep form.

The superficial epithelioma originates chiefly in the rete Malpighii; the deep form, on the contrary, in the sebaceous glands. The superficial epithelioma generally takes the form of diffuse indurations of the skin, which gradually change into flat ulcers, with slightly elevated margins, and slowly spread (rodent ulcers). Cicatrization not infrequently takes place, but, in spite of this, the ulcerative process constantly progresses. The superficial epithelioma spreads more along the surface and less frequently invades the deeper parts. Its course in the face is very chronic. It often has a duration of from ten to twenty years and even more, and does not, as a rule, form metastases.

The deep form of epithelioma originates chiefly in the sebaceous glands and is characterized by a more rapid and more malignant course. Hard nodules or papillary growths are formed, and finally characteristic deep ulcers, with an indurated base. The lymphatic glands are more likely to become involved, and metastases occur in not very rare cases. Very marked destruction of the soft parts and bone is sometimes observed in epithelioma of the face (see Fig. 121). The primary epitheliomata of the mucous membrane, which spread secondarily to the skin, are less common. They usually run a very malignant course.

Etiologically, local irritations of a mechanical or chemical nature are of the greatest significance in connection with the development of epithelioma

of the face. Men are more susceptible than women, and it is seldom observed before the fortieth year. Epithelioma of the lip, which is so very common among men, has been attributed to smoking and to repeated irritation from bad shaving, and carcinoma of the mucous membrane of the cheek has been supposed to be caused by smoking or chewing tobacco, or by sharp stumps of teeth. Epitheliomata not infrequently develop in connection with chronic inflammations of the skin—with lupus, for example (see Fig. 119)—or originate in a cicatrix or a non-malignant tumour—e. g., in cutaneous horns, warts, or atheromata. The tendency to epithelioma is often inherited.

The treatment of an epithelioma of the face consists in its earliest possible removal. This is done with the knife through normal tissue, as far as possible from the edge of the tumour, in order that no germs may be left behind. Resection of the involved part of the upper and lower jaws is frequently necessary. The removal of the neighbouring lymphatic glands is always to be recommended, even when they are not as yet involved. The defect that results is covered, if necessary, by means of a plastic operation (see §§ 29–33). A complete cure can only be secured by early removal; recurrences are the rule. If there has been no recurrence after from eighteen months to two years, the complete cure of the patient may be looked upon as probable. One recurrence usually follows another, until death ensues from exhaustion, from general carcinosis, from hæmorrhages, or from intercurrent diseases, etc.

Fig. 121.—Marked destruction of the face by an epithelioma (Billroth).

The recurrences after epithelioma are in part continuous—that is, they originate from portions of the primary tumour left behind at the time of the operation—and in part regionary, in which case they are to be looked upon as independent new growths in the cicatrix and its vicinity. Regionary recurrences sometimes appear only after years.

Recurrences must also be removed as soon as possible. If they are small and circumscribed, I prefer to remove them by ignipuncture with the small point of a galvano-cautery, a method which I wish to recommend most highly. The cicatrix thus made is not in the least disfiguring.

The use of the thermo-cautery is also to be recommended in connection with large epitheliomatous ulcers. The treatment of inoperable cases is symptomatic (see Principles of Surgery, page 783). We have already mentioned inoculation with erysipelas, which has been recommended for such cases (see also Principles of Surgery, pages 346 and 771).

In Bruns's statistics from the Tübingen clinic regarding the final outcome of operation upon epithelioma of the lip, based upon 866 cases, A. Wörner found that $87\frac{6}{10}$ per cent of all recurrences occurred during the first year after the operation, and concludes that a patient who has remained free from recurrence for three years may be very confidently regarded as completely cured. The permanent cures amounted to $28\frac{1}{10}$ per cent of all those operated upon.

According to Wörner, of 866 cases of epithelioma of the lip, 782 occurred among men and 84 among women. In $94\frac{4}{10}$ per cent of the cases the epithelioma was located on the lower lip, and in $5\frac{6}{10}$ per cent on the upper lip. Epithelioma of the upper lip is more common among women (14·3 per cent) than among men (2·17 per cent).

Of non-malignant epithelial growths, we have already mentioned (page 27) cutaneous horns, which are found on the forehead, on the dorsum of the nose, and on the lips, especially in old women. Cutaneous horns may change into epitheliomata, so that their removal is indicated. In order to avoid recurrence, the underlying skin upon which they rest must be removed at the same time.

Warts, which are often pigmented and covered with hair, occur not infrequently on the face, and should likewise be removed with the knife or by ignipuncture with the fine point of a galvano-cautery, as they are also sometimes the starting point for an epithelioma.

Of non-malignant tumours, originating in the sebaceous glands, I mention the atheromata or sebaceous cysts resulting from the obstruction of the outlet of a sebaceous gland. They are removed in the same way as has been described (page 28). It is important that the sac be removed *in toto*, as otherwise recurrences or fistulæ ensue. A sebaceous cyst may also develop into an epithelioma.

To the follicular cysts belong also the so-called black heads or comedones, due to an accumulation of the thickened secretion of the hair follicles, and also milia, resulting from a similar accumulation of secretion in the sebaceous glands. Both favour the development of furuncles.

Adenomata of the sweat glands have been recently described, especially by Stilling (Deutsche Zeitschrift für Chirurgie, Bd. viii). They form flat, scaly new growths, with numerous very small nodular or sausage-shaped elevations, not infrequently combined with small vesicular cysts. Adenomata of the sweat glands were formerly often called lupus, until more exact histological examination determined their nature. The treatment is similar to that of lupus.

Dermoid cysts which arise from strayed embryonic skin germs (see Principles of Surgery, page 787, and this work, page 29) are not uncommon in the face. They also occur frequently on the skull (see page 29). When in the face, they are located most commonly at the upper border of the orbit, most frequently near its outer part, also in the outer half of the upper eyelid, on the dorsum of the nose, on the forehead, in the temporal region, and in front of and behind the ear. According to Mikulicz, the development of dermoid cysts of the head has a causal connection with the involution of the epidermic layer and with the fœtal clefts. Thus, for example, the formation of dermoid cysts in the neighbourhood of the orbit has to do with the fœtal oculo-nasal pit and with the involution of the epidermic layer for the formation of the lens. The dermoid cysts in the region of the ear have a causal relation, no doubt, with the first branchial cleft. Dermoid cysts always have a deeper location than atheromata, being mostly upon the bone, and there is often found in the latter, in consequence, no doubt, of primary arrest of development, a corresponding depression, which may slowly increase in the later course until there is a complete perforation

of the bone, especially on the skull. Dermoid cysts grow very slowly and seldom attain the size of a walnut. Weinlechner, however, saw a dermoid cyst larger than a hen's egg on the face of a man twenty-two years old.

In removing dermoid cysts one must always bear in mind that the underlying bone may be perforated. The operation should therefore be strictly aseptic and the sac must be removed *in toto*, in order that it may not tear open and parts of it be left behind. In the latter case recurrences ensue and suppuration or erysipelas may be caused by the decomposed secretion which is retained.

Of other cysts which should be included here, the serous cysts—of the cheek, for example—are especially worthy of mention. These have been described by Ranke, Bruns, Güterbock, and others. They are unilocular or multilocular cysts, lined on their inner wall with epithelium. Their contents are usually as clear as water, and they are, no doubt, to be looked upon as cystic lymphangeiomata.

The parasitic cysts due to the echinococcus are very rare in the face. Cases are found in literature reported by Dupuytren and Ricord.

Tumours of the Connective-tissue Type are much rarer in the face than epithelial growths.

I mention, in the first place, the hard and soft fibromata. The soft fibroma is sometimes a circumscribed and sometimes a more diffuse formation, often reaching a very large size (*cutis pendula elephantiasis faciei*). A soft fibroma of this kind is represented in Fig. 122. The skin of the face, the eyes, the mouth, and the nose are often greatly distorted by these large fibromata. It is of interest that, in consequence of the traction and pressure of large, soft fibromata, changes in the form of the skull and the bones of the face not infrequently arise—e. g., asymmetry of the facial portion of the skull, bending, atrophy or wasting of the bones of the face, much as in macroglossia and macrocheilia (Trendelenburg, Murisier). These large, soft fibromata are not infrequently combined with myxoma, or with angcioma and lymphangeioma, so that in cases coming under the last two categories numerous enlarged arteries, veins, and capillaries, or dilated lymph vessels, are found in the tumour.

FIG. 122.—Soft fibroma of the face (elephantiasis faciei) in a woman twenty-four years of age (Schüller).

Congenital moles or birthmarks, which are often pigmented and covered with hair, are in some cases soft fibromata, and sometimes more of the nature of angeiomata.

The treatment of large, soft fibromata consists in partial wedge-shaped excisions, at several sittings it may be, followed by deep suture of the resulting wounds, as already described, page 33.

To the hard fibromata belong also keloids (see Principles of Surgery, page 748), which are almost cartilaginous in character, and appear most frequently on the lobes of the ears, following the formation of holes for earrings. There is developed first a circumscribed induration, then, gradually, a hard, spherical, painless tumour, from the size of a hazelnut to that of a walnut—seldom larger. A recurrence almost always follows their removal. Ignipuncture with the small point of a thermo-cautery or galvano-cautery is often more successful than removal with the knife.

Keloids also result from the ordinary rapier wounds of the face made in students' duels, forming hard, fibrous protuberances. Excision of the same, with the subsequent insertion of coaptation sutures of fine silk and continuous catgut, is to be recommended.

Congenital enlargement of the upper or lower lip (macrocheilia) is conditioned partly upon a diffuse hypertrophy of the submucous connective tissue

FIG. 123.—Plexiform neuroma of the right lower half of the face, the post-auricular region, and the right side of the neck in a boy ten years old (Bruns).

and partly upon the dilatation and new formation of blood-vessels as well as lymph vessels. Sometimes there is chiefly a hypertrophy of the connective tissue (diffuse angeioma), and sometimes the enlarged lip consists mainly of dilated blood-vessels or lymph vessels (cavernous angeioma, lymphangeioma). The more blood-vessels the tumour contains, the softer it is. The lymphangiectatic macrocheilia usually feels firmer and is sometimes so solid that it grates on being cut. The lip often attains a very large size. It usu-

ally has a bluish tint and, owing to its weight, often folds over and sinks downward, so that a decided disfigurement ensues.

Congenital macrocheilia usually has its origin, no doubt, at a very early fœtal period, in consequence of an abnormality of the first branchial arch, as the lower jaw also is usually hypertrophied and curved over in front (Tren-

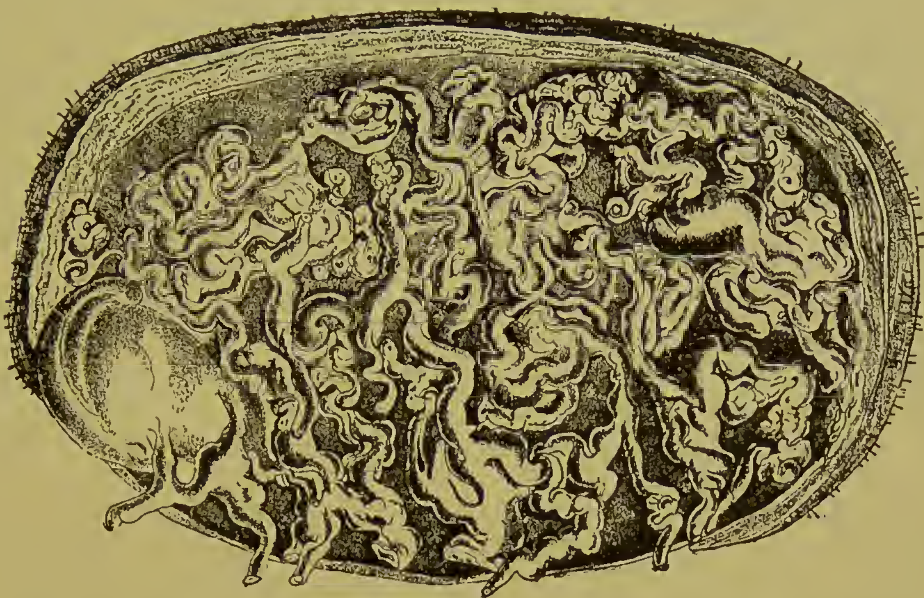


Fig. 124.—Plexiform neuroma: specimen taken from the case shown in Fig. 123.

delenburg). Owing to macrocheilia of the upper lip, the underlying bone may become atrophied secondarily in consequence of pressure (Wegner).

The treatment of macrocheilia consists in making wedge-shaped excisions with subsequent deep suture, or in ignipuncture with a thermo-cautery or a galvano-caustic needle. Mild cases of hypertrophy of the lip, the so-called double lip, are to be distinguished from macrocheilia. We have here to do, in the main, with hypertrophy of the mucous membrane in the form of an abnormal fold or protuberance which becomes visible behind the lip, especially when one speaks or laughs. The same disfiguring condition can also be produced by frequent inflammatory processes.

The treatment of double lip consists in excision of the abnormal fold of mucous membrane by means of a fenestrated forceps and a knife or scissors. The wound is then united by suture with fine silk or catgut.

Lipomata are not very common on the face.

Plexiform neuromata or neurofibromata are sometimes found in the vicinity of the eyelids, the cheek, and the lower jaw (Fig. 123). They are made up of nodular tortuous nerve bundles which have undergone a fibrous degeneration (Fig. 124). They are situated mostly in the subcutaneous cellular tissue. The plexiform neuroma in its external appearance resembles the soft fibroma or elephantiasis—that is, it forms lax, lobulated folds and protuberances of the skin and the subcutaneous cellular tissue, as, for example, in Fig. 122. These are here and there nodular, uneven, and are usually darkly pigmented and covered with hair. The first beginning of the plexiform neuroma always reaches back to the fœtal period. It grows very

slowly. P. Bruns has collected from literature a large number of cases of plexiform neuroma—fifteen in the vicinity of the temples and the upper eyelid, eight in the region behind the ear and on the back of the neck, three of the nose and cheek, four in the region of the lower jaw and front of the neck, seven of the chest and the back, and three of the extremities.

Sarcomata are not often observed in the skin of the face. The cylindroma occurs especially in the neighbourhood of the eye and in the lachrymal gland. Melanotic sarcomata are of special interest, which sometimes develop in connection with moles, pigmented hairy nævi, etc. Pigmented tumours originate most frequently in the choroid of the eye, and have here a very rapid fatal course. I saw, in the case of a child, several secondary pigmented tumours appear upon the skull in a few weeks after removal of the eyeball (Fig. 125). A permanent cure has been rarely secured in cases of well-marked melanotic sarcoma. Recurrences and metastases usually appear very soon. As soon as a mole, a pigmented wart, or a birthmark begins to enlarge, its immediate removal is indicated.

A. Bidder has described a peculiar diffuse, subcutaneous tumour formation on the head and in the face of a butcher sixty-eight years old, which consisted chiefly of lymphoid cells (" diffuse subcutaneous lymphoid," see Fig. 118) (Langenbeck's Archiv, 1877, Bd. xxi).

Aneurisms of the arteries of the face, including the facial, internal maxillary, and the coronary arteries, are not common. They are chiefly traumatic, less frequently idiopathic. For a description of aneurisms of the tem-

Fig. 125.—Melano-sarcoma of the right eye with several secondary tumors (+ + +) on the skull.

Fig. 126. — " Diffuse subcutaneous lymphoid " in a butcher sixty-eight years old (Bidder).

poral artery and arterio venous aneurisms of the temporal artery and vein, see pages 24, 25. The so-called cirsoid aneurism—that is, the dilatation of a number of arterial branches and capillaries with simultaneous hypertrophy of their walls—belongs to the new growths, to angeiomata (see Fig. 17, page 26).

The best treatment of true aneurisms of the arteries of the face consists in central and peripheral ligation of the afferent artery, and in extirpation of the sac.

Angeiomata are very common in the face, constituting, according to Trendelenburg, two thirds of all the angeiomata that occur. The female sex

is most frequently attacked, two thirds of those observed, according to Trendelenburg, being among females. According to Virchow, angeiomata of the face occur especially in the region of the fœtal facial clefts.

One of the most common varieties is the simple angeioma (nævus, plexiform angeioma), which consists of dilated, tortuous, and newly formed capillaries and small arteries and veins. In this class belong the soft, light-red and dark-red teleangeiectases, the congenital nævi, and the pigmented birthmarks which are often covered with hair (see Fig. 127). Many of these hairy birthmarks are more like diffuse soft fibromata, others more like angeiomata. The hairy formation is often similar to the fur of animals—for example, that of rats, monkeys, or hares. It is often asserted by the mothers, as in the case represented in Fig. 127, that during pregnancy they had been frightened by the sudden appearance of those animals whose hair formation their children carry upon their birthmarks. Regarding the abnormal growth of hair upon the face among women (beard formation), and the so-called hairy men, see Principles of Surgery, page 756.

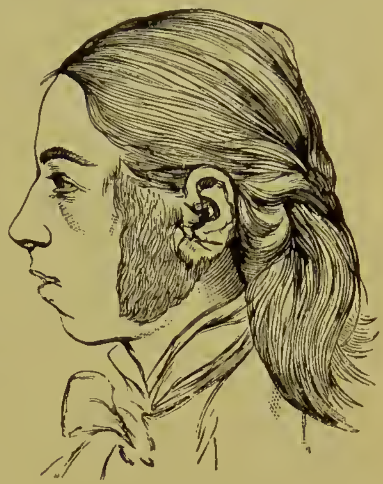


Fig. 127.—Congenital teleangiectasis (birth-mark) with hair-formation (rat-skin) [Mason].

From capillary angeiomata there develop not infrequently very extensive pulsating angeiomata, which rapidly increase in circumference and may involve the greater part of the face or the skull (racemose arterial angeioma or cirsoid or anastomotic aneurism, see Fig. 17, page 26).

In other cases we have a cavernous angeioma (tumour cavernosus)—that is, one consisting of spaces lined with endothelium and filled with fluid or coagulated blood which are separated by connective-tissue partition walls and result from a dilatation of the veins and also of the capillaries. Angeiomata are not infrequently combined with fibroma, lipoma, and sarcoma (angeiosarcoma).

The different forms of angeioma frequently merge into one another. Large pulsating tumours may gradually develop even from simple capillary angeiomata in the form of small congenital nævi. Some congenital angeiomata diminish in size or remain stationary, while others grow more or less rapidly. I saw an angeioma of the thigh the size of a goose egg in an infant which in six months was reduced to a small pigmented spot.

The treatment of angeiomata of the face consists in their removal, if possible, in ignipuncture by means of the galvano-cautery, which was first introduced by Nussbaum, or cauterization with the thermo-cautery. Large vascular nævi are probably also suited to punctate cauterization with the galvano-cautery. Pauli has recommended tattooing them. Pedunculated angeiomata may be removed by the galvano-caustic loop. A cure has also been secured by ligation of the common carotid artery (Bruns), especially in cases of pulsating, cirsoid aneurism. But Heine has shown how rarely cure of these tumours was accomplished by ligation of the common or external carotid artery. Of sixty cases, thirty-two were treated by ligation of the common

carotid, and only three of these patients were cured. Trendelenburg therefore recommends for cases of extensive cirsoid aneurism repeated wedge-shaped excisions from the tumour after ligation, it may be, of the afferent arteries, including the external or common carotid, if necessary.

The parenchymatous injection of tincture of iodine, of liquor ferri chloridi, absolute alcohol, or liquor Piazza (sodium chloride, 15·0; liq. ferri chloridi [thirty per cent], 20·0; aq. dest., 60·0), has also been recommended. The use of caustics is not advisable. Every congenital angeioma, even the smallest red spot, must be carefully watched to see whether it disappears, remains stationary, or grows. If it enlarges, it must be removed immediately with the knife or by ignipuncture.

Lymphangeiomata arising from dilatation of the lymph vessels occur in the face, and especially on the lips, in connection with congenital macrocheilia, which we have already mentioned above.

Weinlechner, Wegner, and others have observed cavernous lymphangeiomata on the forehead and the cheek (macromelia). Steudener described a lymphangeioma of the conjunctiva of the bulb which surrounded the cornea in the form of an annular projecting rim.

The treatment of lymphangeiomata consists, as already stated, in making wedge-shaped excisions or in ignipuncture.

§ 28. **Injuries and Diseases of the Orbit.**—Of the diseases of the orbit brief mention need only be made here of those which have special surgical significance.

Wounds of the orbit have already been discussed in connection with fractures of the skull and injuries of the soft parts of the face (§§ 9, 26). It should be mentioned here, in addition, that severe phlegmonous inflammation, meningitis, and death not infrequently ensue after such injuries of the orbit. Immediate death has repeatedly followed perforating wounds of the orbit with injury to the brain. A case which recently occurred in a fencing club in Vienna is of interest and instructive in various ways. The point of the sabre of one of the contestants entered the orbit of the other, passed into the brain, and occasioned almost instant death. The autopsy showed that the sabre blade had entered the orbit between the bulb and the inner canthus of the eye. The roof of the orbit had been pierced near the small wing of the sphenoid bone, the cavernous sinus opened, the internal carotid artery and the abducens nerve severed, and the sabre point had divided the right crus cerebri and penetrated nearly to the third ventricle of the brain. For the treatment of injuries of the orbit see §§ 9, 26.

Foreign bodies that have penetrated into the orbit easily produce cellulitis, fatal meningitis, and encephalitis. Foreign bodies sometimes heal up within the orbit without occasioning appreciable symptoms, even in cases in which the adjacent portion of the brain has been injured. In other cases they give rise to localized chronic abscesses of the brain.

Injuries of the Eye.—For injuries of the eye I must refer the reader to treatises upon ophthalmology. Only the following brief general statements may be made here :

Injuries of the bulb from blunt force, such as a thrust, a blow, etc., fall into two main groups : (1) Those which do not lead to a division in continuity of the outer wall of the bulb, and (2) those attended with bursting of the bulb from rupture of the sclerotic coat. In the first group there may still be severe intra-ocular injuries—e. g., tearing away of the iris at its ciliary insertion (iridodialysis), and laceration of the ciliary zone with backward dislocation of the lens into the vitreous humour or forward into the anterior chamber of the eye. In the latter case the sphincter of the pupil is simultaneously torn. The tearing away of the iris is characterized by loss of its spherical form, by the projection of a loose corner of the iris into the pupil, and by the presence of a second semilunar pupil. In laceration of the ciliary zone with dislocation of the lens there is present, in addition to the other known symptoms, a distinct flapping of the iris at the slightest movement of the eye. Of other injuries after contusions, there may still be mentioned traumatic paralysis of the iris (iridoplegia) with or without paresis of the ciliary muscle, dimness of the lens (traumatic cataract), rupture of the anterior capsule of the lens, hæmorrhages into the vitreous humour, rupture of the choroid membrane, rupture and detachment of the retina, and opacity of the retina (Berlin's commotio retinæ).

All injuries of the eyes which, aside from other possible internal injuries, are complicated by rupture of the sclerotic coat, may lead, by the entrance of germs of infection, to an acute or a more chronic ophthalmia, and thereby destroy to a greater or less extent the function of the eye. The other uninjured eye may also be drawn into sympathy by propagation of the inflammation along the lymph passages of the optic nerve. Every rupture of the sclerotic coat should be treated with strict observance of antiseptic rules, and at the first sign of sympathetic ophthalmia energetic measures must be taken.

Of the diseases of the orbit I mention here especially orbital cellulitis, which may, by causing thrombosis of the ophthalmic vein, lead to suppurative meningitis and sinus thrombosis. The principal symptoms of orbital cellulitis are an abnormal prominence of the eye (exophthalmos) and more or less fixation or limitation of movement of the bulb. Thrombosis of the ophthalmic vein and the cavernous sinus sometimes takes place after comparatively slight injuries in the region of the eye, which are not treated under antiseptic precautions, or after even slight inflammations, such as, for example, acne pustules. The treatment of orbital cellulitis consists in the speediest possible incision and drainage of the orbit by opening the orbital cavity with a pointed knife, above or below the eye, close to the border of the orbit, carefully avoiding the bulb.

Pulsating Exophthalmos.—An arterio-venous aneurism involving the internal carotid artery and the cavernous sinus gives rise as a character-

istic symptom to pulsating exophthalmos (Nélaton, Rivington, Schläfke). It was formerly supposed that pulsating exophthalmos was conditioned chiefly upon aneurism of the ophthalmic artery, or upon racemose arterial angeioma in the orbit.

The symptoms of pulsating exophthalmos are protrusion of the pulsating bulb, swelling of the lids, ectropion of the lower lid, dilatation and often pulsation of the orbital veins. When the carotid artery is compressed, the pulsation of the eye and of the veins ceases, and upon removal of the pressure it immediately returns. Sight may remain unimpaired.

The treatment of pulsating exophthalmos consists in ligation of the common carotid artery (see § 90). According to Nieden, of forty-nine cases, thirty-three were cured by ligation of this artery and in six there was improvement. In three cases the treatment was without effect and in seven death ensued (see also page 115). Wölfler and others obtained good results from compression of the carotid artery—e. g., for from eight to ten days.

The ordinary non-pulsating exophthalmos is most commonly caused by phlegmonous inflammation and tumours, sometimes also by emphysema of the orbit.

Emphysema of the Orbit occurs usually after fractures of the neighbouring facial cavities which contain air, so that there is open communication with the orbital cavity—that is, particularly after fractures or carious processes involving the antrum of Highmore, the ethmoid bone, the lachrymal bone, and the frontal sinuses; also after rupture of the lachrymal sac without fracture of the lachrymal bone. The most important symptoms of orbital emphysema are protrusion of the bulb (exophthalmos) with restricted movement of the same, and usually corresponding emphysema of the eyelids. If a light dressing which exerts pressure is applied, and if the patient is careful to avoid all deep respiratory movements, especially blowing the nose, the emphysema usually disappears in a few days.

Tumours of the Orbit (Fig. 128) originate mostly in the bulb or its surroundings, and especially in the frontal sinuses (see page 179). In the orbital cavity itself melano-sarcomata (see Fig. 125, page 220) and glio-sarcomata of the bulb, retrobulbar sarcomata, angeiomata, etc., are the most common. Dermoid and echinococcus cysts have also been repeatedly observed. Congenital cysts in the neighbourhood of the eye, with oil-like contents, are to be regarded, no doubt, as dermoid cysts (Verneuil, Perrin, Albert). The prelachrymal region is a favourite place for these oil cysts. In all orbital tumours increasing exophthalmos occurs, and here also the movements of the bulb are

either more or less disturbed or wholly suspended. In consequence of pressure, the bulb may gradually undergo increasing atrophy.

Echinococcus cysts of the orbit are identical with those in other parts of the body. Hooklets are less frequently found here in the cyst fluid. According to Dieu, echinococcus cysts of the orbit are more frequent among men than among women. Of twenty-four cases found in literature, eighteen were males and only six females. They are usually characterized by severe pain, by marked inflammatory symptoms in the neighbourhood, and by exophthalmos. The course is, as a rule, very slow.

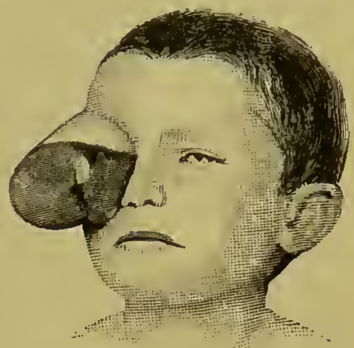


FIG. 128.—Small round-celled sarcoma of the right orbit, with preservation of the bulb, in a boy of nine; extirpation; death one and a half years after the operation from a recurrence that perforated into the cranial cavity.

The diagnosis, which is best made by puncture, is easy as soon as the cyst can be felt from the outside.

The prognosis is good, so far as the life of the patient is concerned, and the earlier the cyst receives operative treatment the better the prospect of preserving the sight. As, however, the affection does not come under operative treatment until very late, the sight has usually already been destroyed by compression or destruction of the optic nerve or the bulb. Treatment consists in incision and drainage of the cyst, or, if possible, in its excision.

Between the lower and upper eyelid and the border of the orbit prolapsed pouches of fat are sometimes observed which have been called adipose-tissue hernias. They are due, no doubt, to a lax condition of the tarso-orbital fascia such as occurs especially among older people. The treatment consists in incision of the skin and removal of the prolapsed adipose tissue. A similar condition arises from an elephantiasis-like hypertrophy of the skin and the subcutaneous cellular tissue, which is overcome by excision of an elliptical strip of skin and subcutaneous cellular tissue.

Enucleation of the Eyeball is performed most commonly for primary malignant tumours of the bulb and for secondary involvement of the eye by epitheliomata of the skin, for example. The operation is performed with small mouse-tooth forceps and curved scissors. The enucleation is begun by severing the internal palpebral ligament at the inner canthus of the eye, and then dividing the line of reflection of the conjunctiva and the points of insertion of the muscles of the eye on the bulb by cutting around the latter with curved scissors. The bulb is finally drawn a little forward and the optic nerve is then divided with the scissors as far back as possible in the orbit. The eyelids are always

preserved if possible. In case of malignant tumours the fat of the orbital cavity must also be removed as completely as possible. After the hæmorrhage has been arrested the orbit is packed with iodoform gauze and an antiseptic protective dressing is applied. The defect is remedied, after the wound has healed, by an artificial eye.

In order to modify the repulsive appearance of the patient after clearing out the orbital cavity, which is often but little improved by wearing a glass eye, E. Küster has covered over the cavity by suture of the lids, or by means of a pedunculated flap taken from the temporal and frontal regions.

§ 29. **General Remarks upon Plastic Operations on the Face.**—In order to remedy the defects in the face arising from the extirpation of tumours, from injuries or from inflammatory processes, we make use of plastic operations, the general principles of which have already been briefly described in our treatise upon Principles of Surgery, §§ 41–43. We shall take up here only the transplantation of pedunculated flaps from the immediate neighbourhood of the defect. With reference to the transplantation of pedunculated flaps from more remote parts of the body and of wholly detached flaps, as well as Reverdin's and Thiersch's methods of skin-grafting, the reader is referred to Principles of Surgery, §§ 41, 42.

The plastic operations on the face are mainly the following: First, plastic restoration of the eyelids (blepharoplasty); second, partial and complete plastic restoration of the nose (rhinoplasty); third, plastic restoration of the cheek (meloplasty); fourth, plastic restoration of the lips and mouth (cheiloplasty and stomatoplasty); and finally, fifth, plastic restoration of the ear (otoplasty). In the sections that follow (§§ 30–34) only the plastic restoration of the eyelids, the cheek, the lips, and the mouth is described. For plastic restoration of the nose (rhinoplasty) the reader is referred to the sections on the surgery of the nose (§ 42), and for that of the ear (otoplasty) to those on the surgery of the ear (§ 72).

Defects in the face are either fresh—e. g., after the extirpation of tumours—or older, granulating or already cicatrized. In the case of cicatrized defects the operation begins with freshening their edges. In every plastic operation one should arrange beforehand a definite plan of procedure. The different parts of the skin of the face are not equally serviceable for plastic operations. The skin of the forehead, the temples, and the nose is very well adapted for this purpose, that of the cheek is less serviceable, and that of the front and back of the neck has still less value. Every plastic operation must be performed in strict accordance with antiseptic principles, as only in this way as well as by careful suture can primary union be secured.

The flaps used for plastic work must consist of as sound skin as possible. Cicatrices which involve the whole thickness of the skin endanger the vitality of the flap. The flap is either cut free hand, or, if its form is complicated, a piece of adhesive plaster of a corresponding shape is applied and the knife made to follow its contours. Care must be taken not to make the flap too small. Generally speaking, it should be in every dimension about one third larger than the defect. It is carefully dissected up from the subjacent tissue without too much traction. The pedicle—that is, the bridge that connects the flap with the rest of the skin—must contain sufficient vessels, but it is not a good plan to have it very wide, as it thus loses in mobility.

Gersuny was the first to show that flaps can be successfully used for plastic operations, especially for defects in the mucous membrane, whose pedicle consists of subcutaneous tissue only. The flap is simply folded over into the defect like a folding door or drawn into the proper cavity, etc., through a slit shaped like a wide buttonhole.

Granulating flaps of skin are sometimes used to advantage, or flaps that are skinned over, e. g., in connection with defects of the oral cavity—that is, the wound surface of the pedunculated flap, before it is made to heal in place, is covered with Thiersch's skin-grafts.

When the flap is laid into the defect one must see to it that the pedicle is not too much twisted and that the sutures cause no tension on the flap. Movable flaps which can be easily turned without undue compression of the pedicle are best secured by prolonging one end of the incision near the pedicle in a curve extending backward (see Figs. 129 *a* and 129 *b*). The flap is finally secured in place by interrupted sutures of fine aseptic silk and, if necessary, by continuous suture with fine catgut, and the secondary defect caused by the removal of the flap completely closed by suture, if possible, or, immediately after arrest of the hæmorrhage or on the next day, covered with grafts taken from the inner side of the upper arm, for instance. Dressings are often unnecessary after plastic operations. A little vaseline and iodoform powder are not infrequently sufficient. Where it is practicable, however, I usually apply antiseptic protective dressings. The pedicle must not be compressed in the least by these dressings. The sutures are removed on from the third to the fifth day. Single sutures here and there may be removed twenty-four hours after the operation. If the flap dies, either the operation or the after-treatment is, as a rule, at fault.

The nerve conduction is usually very soon re-established—e. g., after rhinoplasty the sensory impressions in a few days are correctly localized by the patient in correspondence with the new location of the flap.

Plastic flaps diminish very much in size as time goes on, and we shall learn, especially in connection with rhinoplasty, various methods by which this is to be prevented. All flaps that contain mucous membrane shrink much less.

§ 30. **Blepharoplasty.**—By blepharoplasty is understood plastic operation for remedying defects and deformites of the eyelids.

Blepharoplasty is most frequently performed for cicatricial ectropion, or eversion of the eyelids in consequence of cicatricial contraction following inflammatory processes (lupus, syphilis, caries and necrosis of the border of the orbit, etc.), wounds, burns, etc. Ectropion develops most frequently on the lower eyelid, sometimes on both lids, and, in rare cases, on all four at the same time. Blepharoplasty is also used in remedying defects following the removal of tumours.

Moreover, marked defects on the eyelids, just as upon the lips and the cheek, may be closed without plastic operation by stretching, sliding over, and detaching the borders of the defect.

The best form of blepharoplasty for restoring a lower eyelid is that devised by Fricke, in which a flap is taken from the temple (Fig. 129 *a*),

Fig. 129 *a*. Fig. 129 *b*. Fig. 129 *c*.

Blepharoplasty: *a*, Fricke's method; *b*, modified by Ammon and Langenbeck; *c*, after suture of *b*.

or Fricke's method as modified by Ammon and Langenbeck, according to Fig. 129 *b*. Fig. 129 *c* shows the latter method after suture. It is very important in blepharoplasty that, as Langenbeck was the first to emphasize, the end of the incision should be prolonged a little backward in a curve, and that the pedicle should not be made too broad, in order that flaps may be obtained which are as movable as possible and which can be turned easily. Fig. 129 *b* represents in the main the method which Langenbeck always used, and which Trendelenburg also properly recommends. The flap must be made wide enough in blepharoplasty to overcorrect the deformity—that is, to produce a certain amount of inversion of the lid (entropion).

In partial ectropion one may also make a V-shaped incision upon the lower lid, according to Fig. 130 A. The triangular flap *a b c* is then dissected up from the incisions *a d* and *c d*, and, together with the lid, is pushed upward, and the wound finally closed by a Y-shaped line of suture (Fig. 130 B).

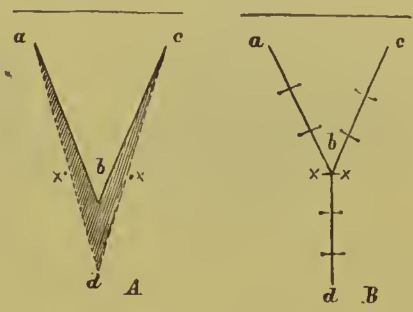


Fig. 130.—Operation for partial ectropion.

Large, triangular defects on the lower eyelid—e. g., following the removal of a tumour—may be closed, after Dieffenbach (Fig. 131 *a*), by a flap taken from the side of the cheek. To prevent the newly formed lid, as far as possible, from being drawn outward, the sutures are inserted as represented in Fig. 131 *b*, and the defect on the side is skin-grafted.

I have also closed defects on the lower lid repeatedly, with good results, by the use of Thiersch's skin-grafts (see Principles of Surgery, § 42).

Blepharoplasty of the upper eyelid is performed in accordance with the same rules essentially as those just given for the lower lid. Here also, in case of partial ectropion, the V-shaped freshening and the Y-shaped suture are used as well as the methods of Fricke and Langenbeck-Ammon, as represented in Fig. 129 *a b c*, except that the pedicle must be somewhat higher up, and the form of the flap inverted—that is, the inner boundary line of the flap in Fig. 129 *a* and *b* now becomes the outer one, and the outer one lies on the inside. Skin defects on the upper lid may also be skin-grafted.


Fig. 131 *a*. Fig. 131 *b*.
Dieffenbach's method of blepharoplasty (*a*); *b*, condition after suture.

The principles of the operation are, in short, always the same, whether one operates upon the upper or the lower eyelid.

If defects are to be remedied on both eyelids—e. g., after the removal of a carcinoma at the corner of the eye—one may proceed, according to the method of Hasner von Artha, by forming two sickle-shaped flaps from the skin immediately adjoining the defect (Fig. 132).

In every blepharoplasty the palpebral portion of the conjunctiva is of course preserved. When there are cicatricial defects, the cicatricial

adhesions must first be divided by making an incision close along the ciliary border and then cautiously working in deeper until the edge of the lid can be brought into its normal place with small hooks. The floor of the resulting semi-elliptical defect is formed by the conjunctiva, and the flap from the temple or the cheek is sutured into this defect, according to Fig. 129 *a*, for example, or, better, according to Fig. 129 *b*. Defects of the conjunctiva may be remedied by the transplantation of mucous membrane after Wölfler.

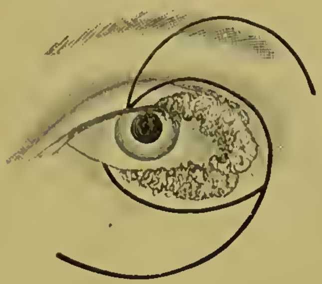


Fig. 132 *a*.

Fig. 132 *b*.

Blepharoplasty on both lids (Hasner von Artha): *a*, formation of two sickel-shaped flaps from the vicinity of the defect; *b*, condition after suture.

Tripier restored the lower eyelid by drawing down the upper lid and forming from it a bridge-shaped flap. The flap contains not only the skin but the fibres of the orbicularis palpebrarum as well, which is kept as intact as possible. The flap remains connected with the subjacent parts at the inner and outer canthus. In case of defects on the upper eyelid, the flap should be taken from the forehead. The contractility of the muscular fibres that were transplanted at the same time could be distinctly demonstrated by means of the faradic current. Tripier emphasizes as an advantage of his method the fact that, in forming the skin-muscle flap, the incision is made as precisely as possible in the line of the muscle and nerve fibres, so that their function is preserved in their new location.

§ 31. **Cheiloplasty.**—By cheiloplasty is understood the remedying of defects upon the lips by plastic operation, which we have already partially considered when treating of harelip.

In what follows regarding plastic operations on the lips we have in mind mainly the defects which arise from the removal of tumours, particularly epitheliomata. Older, cicatrized defects are treated in precisely the same manner, after freshening their cicatrized edges.

I. **Plastic Operations on the Lower Lip.**—Epitheliomata of the lower lip are removed, as we have seen, with the knife or scissors, through normal tissue, at a distance of about one centimetre from the edge of the tumour. The hæmorrhage from the coronary arteries is controlled by means of artery clamps, by a temporary suture, or by the hands of an assistant.

Smaller defects, whether triangular or more curved in outline, are closed without a plastic operation by traction upon the extensible portions of the lip, and in this way very considerable defects may be cov-

ered. After the removal of superficial epitheliomata by a slightly curved incision with the scissors or the knife, one may unite the edge of the mucous membrane with the vermilion border of the lip, as shown in Fig. 133. In wedge-shaped defects the line of suture runs perpendicularly.

FIG. 133.—Method of suture after removal of a superficial epithelioma of the lip.

Larger triangular defects, which can not be closed by simple suture without great tension, may be treated as shown in Fig. 134 *a*—that is, the oral aperture is widened by a horizontal incision from the corner of the mouth on each side and sutures are inserted as represented in Fig. 134 *b*.

If a longitudinal incision parallel to the border of the defect is added to the horizontal incision on each side, we have the method of Dieffenbach (Fig. 135 *a*). A modification of Dieffenbach's method, which was suggested by Jäsche (see Fig. 135 *b*), is very serviceable, especially for extensive defects on the lower lip—that is, for complete cheiloplasty. By this latter method the incisions at the corners of the mouth are only made down to the mucous membrane. The latter is then dissected up and cut through somewhat higher, corresponding to the dotted lines. This flap of mucous membrane at the corners of the mouth is used on each side in forming a border for the new lip. A single flap, similar to the one shown in Fig. 135 *b*, is often sufficient, but it must then be made somewhat broader, particularly near its pedicle.

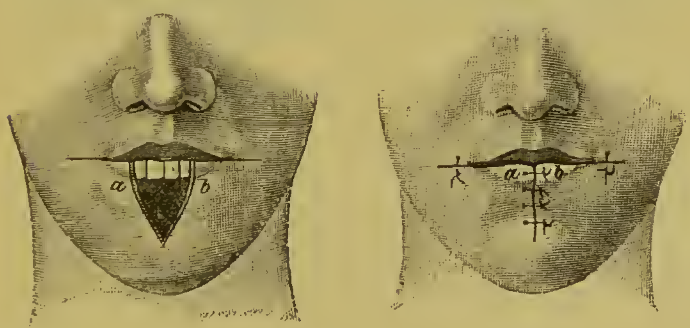


FIG. 134 *a*. FIG. 134 *b*.

Cheiloplasty with the aid of lateral horizontal incisions.

The method of Syme-Buchanan is represented in Fig. 136, that of Blasius in Fig. 137. The method devised by Blasius is especially adapted for obliquely placed, triangular defects. The freeing incision is carried obliquely from the lower corner of the wound toward the opposite (sound) side, and the triangular flap thus formed is then detached from the jaw. Lateral, triangular, partial defects of the lower lip are very satisfactorily closed by Estlander's method (see Fig. 138), in which a flap is taken from the upper lip, its nutritive bridge being at the vermilion border. The flap is dissected up and turned into the defect on the lower lip. Fig. 138 *b* represents the wound after suture.

One can also close partial, laterally placed defects of the lower lip from the upper lip by making an incision around the lower and the

Fig. 135 *a*.

Fig. 135 *b*.

Cheiloplasty with lateral flaps: *a*, Dieffenbach's method; *b*, Jäsche's method.

Fig. 136.—Cheiloplasty (Syme-Buchanan).

upper lip, as represented in Fig. 139, and then drawing the edges of the vermilion border together and inserting sutures (Langenbeck). (See also the analogous method represented in Fig. 142.)

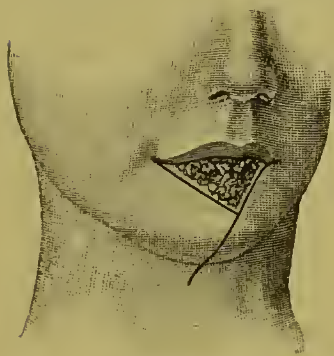


Fig. 137.—Cheiloplasty (Blasius).

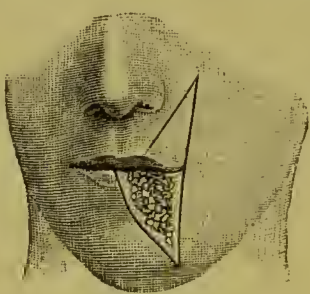


Fig. 138 *a*.

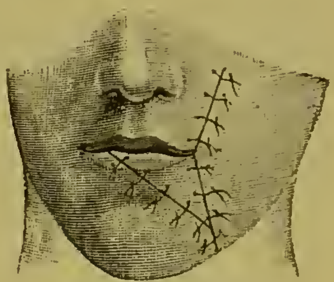


Fig. 138 *b*.

Partial cheiloplasty (Estlander).

Complete losses of substance of the lower lip having a quadrilateral or semicircular form may be remedied by Bruns's method (Fig. 140) or by that of Langenbeck (Fig. 141). Bruns cuts the flap from the cheek,

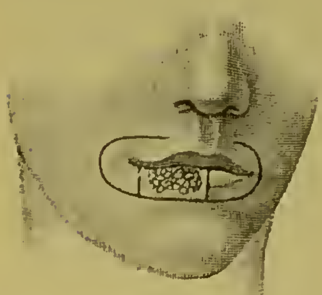


Fig. 139.—Cheiloplasty with displacement of the border of the lip (Langenbeck).

Fig. 140 *a*.

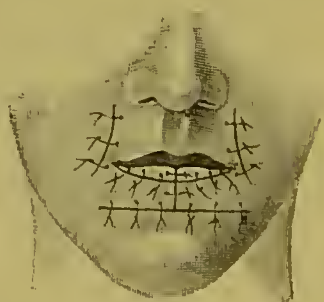


Fig. 140 *b*.

Cheiloplasty with the formation of two flaps from the cheeks: *b*, after suture.

turns this into the defect and sutures it in place as shown in Fig. 140 *b*. Langenbeck takes a flap from the region of the chin (Fig. 141 *a* 1), turns it upward into the defect and sutures it according to Fig. 141 *b*.

Wherever one uses flaps without the vermilion border of the lip for covering losses of substance, one may, as has been shown in Fig. 139, dissect up the vermilion border of the upper lip and use this to cover over the edges of the flap and thus complete the formation of the lip (Fig. 142). The oral aperture, which is at first roundish, soon assumes a more normal form. Morgan and Wölfler use for covering the defect—e. g., after removal of an epithelioma of the lower lip—a bridge-shaped flap from the skin under the chin, making a curved incision about twelve centimetres in length along the lower jaw, parallel

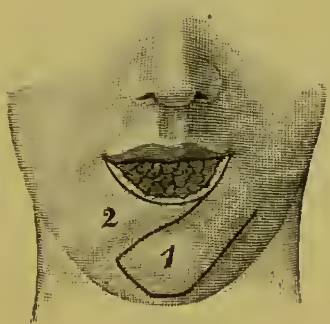


Fig. 141 *a*.

Fig. 141 *b*.

Cheiloplasty with the formation of a flap from the chin: *b*, after suture (Langenbeck).

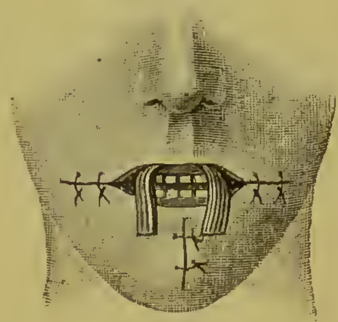


Fig. 142.—Restoration of the vermilion border of the lower lip by dissecting up and displacing the mucous membrane of the upper lip.

to the border of the defect. After detaching the bridge of skin from the subjacent parts, it is pushed upward into the defect (Regnier).

II. **Plastic Operations on the Upper Lip.**—Plastic operations on the upper lip are much less common than those upon the lower lip.

Larger defects may be covered by Dieffenbach's method of incision (143 *a*). Curved incisions are made around the alæ nasi, and these, as well as the margins of the defect, are detached from the bone, and sutures are inserted, as shown in Fig. 143 *b*.

Larger defects of the upper lip can also be made good by forming lateral flaps from the cheek (see Fig. 144), which are turned into the defect after detachment from the bone. The formation of two similar but lower flaps from the lateral region of the cheek and chin, after Sédillot, is also a very good method. An incision is carried directly downward from the corner of the mouth through the entire thickness of the soft parts. The base—that is, the connecting bridge of the flap—is at the corner of the mouth. This method of Sédillot's can also be advantageously applied in performing cheiloplasty on the lower lip.

Estlander's method for the lower lip (Fig. 138) can also be used for cheiloplasty on the upper lip by taking a corresponding flap from the lower lip. The flaps for restoring the upper lip must, in the same way, be bordered with mucous membrane from the lower lip.

The bordering of the free margins of the lip with mucous membrane is always very important, mainly for the reason that the cicatricial contraction is thereby much diminished. In every case of cheiloplasty, therefore, the mucous membrane should be preserved as far as possible —e. g., that on the inner surface of the lower or upper lip or the cheek should be detached, if possible, in the form of pedunculated or bridge-shaped flaps, and united with the external wound surface. In suitable cases, flaps that are covered with skin-grafts, after Plessing and Thiersch, may be used, or transplanted mucous membrane, after Wölfler.

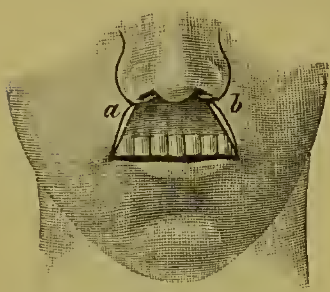


Fig. 143 *a*.

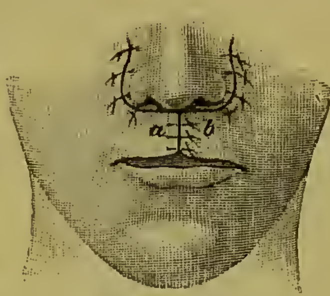


Fig. 143 *b*.

Cheiloplasty on the upper lip: *b*, after suture (Dieffenbach).

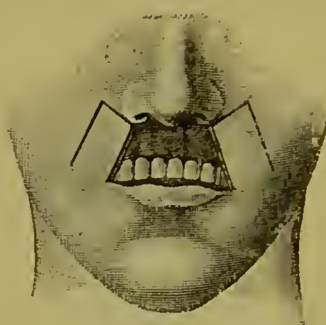


Fig. 144.—Cheiloplasty on the upper lip.

The operation for ectropion—that is, eversion of the lip—is performed in essentially the same way as in blepharoplasty. In the milder forms of this eversion—e. g., of the lower lip—in consequence of a cicatrix that runs downward, one may excise a wedge-shaped piece from the scar, or take the same course as in partial ectropion of the eyelid, as represented in Fig. 130, making a V-shaped incision about the scar, dissecting it up, and then suturing so as to make a Y.

In severe cases of ectropion—e. g., of the entire lower lip—an incision is made close beneath the margin of the lip, the margin is dissected up somewhat and brought into its normal position, and the elliptical defect is then closed by a pedunculated flap from the cheek or from the chin.

Essentially the same methods are used in operating upon the upper lip.

§ 32. **Stomatoplasty.**—Plastic operations on the mouth are performed partly for congenital or acquired defects and partly for cicatricial contraction of the oral aperture. Congenital enlargement of the mouth (macrostoma) was mentioned when we treated of harelip. The operation is performed in essentially the same way as for the latter and the other clefts of the face. Acquired macrostoma, from defects

following noma, for instance, is remedied according to the rules for cheiloplasty (see § 31) or meloplasty (see § 33).

We shall here occupy ourselves particularly with stomatoplasty for cicatricial contraction of the oral aperture (atresia of the mouth, microstoma). This cicatricial contraction of the mouth, which is sometimes extreme (Fig. 145), is usually a result of inflammatory and ulcerative processes. It is seldom congenital.

Fig. 145.—Contraction of the oral orifice in a man forty-four years of age, due to lupus.

Dieffenbach's operation for atresia of the mouth is performed by excision, in the first place, of a narrow strip of skin from the contracted oral aperture to the point where the new corner of the mouth is to be placed. The mucous membrane, which at first is left untouched, is then, after excision of the narrow strip of skin, divided horizontally in the middle, and the two strips of mucous membrane thus obtained are sutured to the outer skin. It is simpler and equally efficacious to divide the skin and the mucous membrane from the oral aperture to the neighbourhood of the new corner of the mouth at the same time, then to make the mucous membrane movable by dissecting it up from the overlying parts, and to suture it to the outer skin. If the mucous membrane is too rigid, in consequence of cicatricial changes, so that it is not adapted for a vermilion border, the edges of the wound are bordered in a similar way with the outer skin. The chief thing in stomatoplasty consists in securing a good border at the new corner of the mouth, and the mucous membrane must therefore be dissected up for a considerable distance here. One may also form a triangular flap of mucous membrane at the new corner of the mouth by making the incision here -<-shaped. Unfortunately, in spite of the greatest care in operating, recurrences, in consequence of renewed cicatricial contraction, can not always be avoided. Hueter therefore recommends that after the operation, or after healing has taken place, an artificial mouth of hard India-rubber be worn—that is, a ring of hard India-rubber with a horizontal plate; the latter is laid between the teeth and the lips so that the artificial mouth is held in place of itself.

§ 33. **Meloplasty.**—The plastic operations for restoring fresh or older defects in the cheek are very manifold, so that it is difficult to give rules for them. Smaller losses of substance are closed by simple suture after drawing together the edges of the wound, which are here very extensible. In case of larger defects, the loss is made good by means of pedunculated flaps from the region of the forehead, the temples, the upper

jaw, the lower jaw, or the chin—as represented in Fig. 146, for example—in much the same way as already described for blepharoplasty and cheiloplasty. The skin of the neck is of little use for plastic operations, as it shrinks too much. Troublesome cicatricial contractions may also easily arise at the site of the defect on the neck. In every plastic operation on the cheek care must be taken that the lower eyelid and the upper lip are not distorted. Superficial defects which involve only the outer skin can be closed by skin-grafting.

Meloplasty is especially difficult when the entire thickness of a large part of the cheek has been lost, from noma, for instance (see page 208, Fig. 117), and the borders of the defect are attached to the jaws by cicatricial adhesions (cicatricial lockjaw). In milder cases of cicatricial lockjaw without loss of substance, stretching the scar or its horizontal division from within the mouth with detachment, it may be, of the cicatricial mass from the jaws, is sufficient for separating the teeth, which are firmly pressed together. In these milder cases the object may be accomplished by introducing wooden wedges or grooved cones of wood between the teeth, which the patient forces farther and farther into his mouth, and finally by the use now and then of Roser's mouth gag. These methods, however, do not suffice for the more severe cases of cicatricial lockjaw, as the condition would constantly recur.

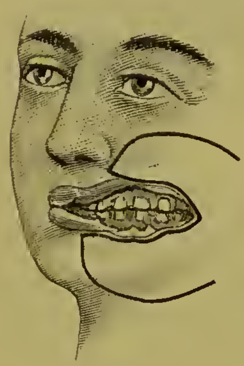


Fig. 146 *a*.


Fig. 146 *b*.

Meloplasty by the use of two pedunculated flaps from the cheek and chin (*a*): *b*, condition after suture.

A very excellent method used by Gussenbauer is adapted to such cases. It consists in dividing the cheek and implanting a doubled flap in the defect. In Gussenbauer's case (Fig. 147) there was cicatricial lockjaw resulting from ulcerative mercurial stomatitis terminating in gangrene, the patient being a boy seven years of age.

Gussenbauer cut from the skin of each cheek a flap four centimetres broad in front and six centimetres broad behind. These were dissected up as far as the edge of the masseter, and had their pedicle here. The subcutaneous soft parts of the cheek and the cicatrices were now likewise transversely divided as far as the border of the masseter. The flap of skin on each side, that had been dissected up, was now turned into the defect in such a way that its anterior border could be sutured to the mucous membrane which was still preserved behind the masseter, and its outer epithelial surface directed toward the oral cavity. After four weeks, the pedicle of the flap that had

now healed in was divided on each side, and the posterior part of the flap was detached from behind forward and turned into the portion of the defect that still remained, so that the epithelial side of the entire flap was now directed toward the oral cavity. In suturing the flap in place, the border of the cleft in the cheek on the upper and lower jaws was used to form new gums. Finally, the outer defect in the cheek was covered by a rectangular flap of skin from the border of the lower jaw with its base above and posterior. The result was excellent (see Fig. 147). After fifteen months the boy could open his mouth so that the incisors of the upper and the lower jaw stood two centimetres apart. The portion of skin lying within the oral cavity had taken on the appearance of mucous membrane.

Fig. 147.—Restoration of the cheek and mouth (Gussenbauer).

The above-described, very ingenious method used by Gussenbauer is only practicable when there is sound skin in sufficient quantity in the vicinity of the cicatricial lockjaw. In cases of loss of substance in the cheek with cicatricial lockjaw—after noma, for instance—one may cover the defect after freshening and detaching its borders, as Trendelenburg also recommends, with one or two flaps of skin from the posterior region of the cheek, the temple, the lower jaw or the chin, and suture them so that their skin surfaces are turned toward the inside of the mouth. The outer wound surface is covered later by skin-grafting, or by a second flap. The methods of Israel and Hahn, mentioned below and on page 238, are very useful. They cut a very long flap and, after allowing it to heal into the defect and severing its pedicle, double it together. Still simpler are the methods of Gersuny, Czerny, and Kraske (see pages 238 and 239). The transplantation of mucous membrane recommended by Wölfler can also be used to advantage for restoring mucous membrane in meloplasty, and the latter is thereby simplified. If there is still sufficient mucous membrane in the oral cavity, one can supply the portion that is wanting by a flap taken from the mucous membrane of the mouth—from the hard palate, for instance (Gussenbauer, K. Bayer). The outer defect in the cheek is closed by a skin-flap. The operation can be done in one sitting.

When the cicatricial lockjaw can not be permanently overcome by stretching the cicatricial bands, or by operative means, there often remains nothing to do except, by the extraction of teeth, to make an opening for the introduction of fluid nourishment, or to make the lower jaw movable by the formation of a pseudarthrosis, or, finally, to

resect the ramus of the jaw from the corner of the mouth to the temporo-maxillary articulation. Rose resected, in one case, not only the joint but also the entire zygoma.

Thiersch, in one case of plastic operation on the cheek, covered the flap over with skin-grafts before implanting it in the defect. This method is less adapted for large defects on account of the great shrinkage of the flap.

Israel restored the skin and mucous membrane of the cheek, in the case of a man seventy-one years of age, by a single, very long flap from the side of the neck and supraclavicular region, as far down as the clavicle. The pedicle was situated just below the angle of the jaw (Fig. 148 *a*). The flap, after being dissected up, was turned over, and its anterior half placed in the defect, with the skin surface directed toward the oral cavity, and its upper and lower borders were united with the corresponding borders of mucous membrane (Fig. 148 *b*). After seventeen days the pedicle was divided, the posterior part of the flap was turned over forward and, after scraping off the outer granulating surface, was sutured to the anterior free border. The upper and lower borders of the flap were united with the skin borders of the defect after previous freshening (Fig. 148 *c*). The remainder of the operation then consisted in bordering the corner of the mouth by dissecting up the mucous membrane of the upper and lower lips, and in the fourth sitting the still existing access to the oral cavity between the posterior border of the double flap and the posterior border of the defect was closed by freshening the double flap and uniting its inner layer with the mucous membrane and its outer layer with the skin of the cheek.

Hahn operated in much the same way as Israel. He took a very long flap from the region of the chest. After it had healed, the pedicle was

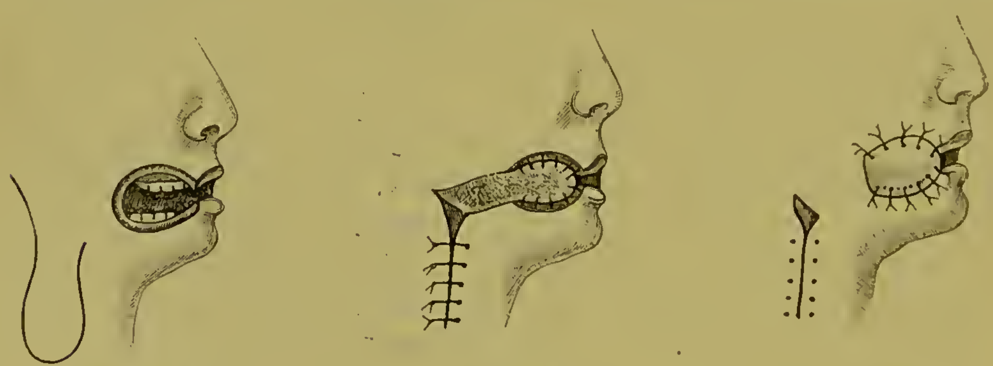


Fig. 148 *a*. Fig. 148 *b*. Fig. 148 *c*.

Meloplasty (Israel).

severed and the flap turned over, so that its oral surface as well as its outer surface was covered with epidermis.

Czerny, in a case of large defect in the cheek resulting from the excision of an epithelioma, formed a flap from the cheek and neck whose base, corresponding to the zygoma, reached in a lateral direction from the defect as far as the ear. Its rounded tip lay at about the middle of the posterior border of the sterno-mastoid muscle. The flap contained the platysma, and

was so long that it could be carried around the corner of the mouth and turned inward. The flap, thus doubled, was sutured into the defect of the cheek, so that the hairless skin of the neck—that is, the tip of the flap—lay inside the mouth. The double flap was united by catgut suture with the mucous membrane on the inside and with the skin of the cheek on the outside. The defect caused by the removal of the flap could be almost wholly closed by suture.

Keetley closed a very large defect of the cheek by means of a pedunculated flap from the skin of the upper arm.

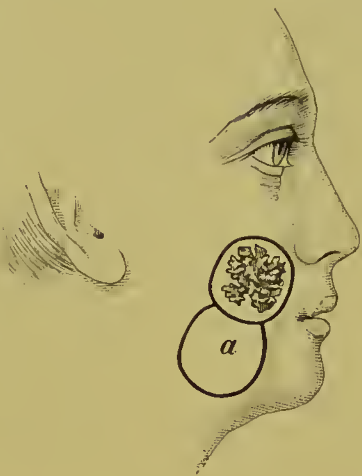


Fig. 149 *a*.

Fig. 149 *b*.

Meloplasty (Kraske).

Gersuny closed a defect of the cheek in one case with a flap of skin whose pedicle consisted only of subcutaneous tissue. This method, which was also successfully used by Hacker, shows that flaps of skin are sufficiently nourished by a pedicle of subcutaneous tissue, so that they may be used for plastic purposes. The flap which is taken from the immediate surroundings and completely severed, except at its pedicle, of subcutaneous tissue, is turned into the defect on its pedicle, like the wing of a folding door, or brought into its place through a slit or buttonhole in the skin. This very simple method, which accomplishes the purpose quickly, is to be recommended also for cicatricial lockjaw.

Kraske, in two cases, closed defects of the cheek successfully in the following manner: A flap of skin was formed (Fig. 149 *a*) from the immediate neighbourhood and was dissected up to within about one centimetre from the border of the defect. The nutritive pedicle consisted of subcutaneous cellular tissue and mucous membrane. The flap was sutured into the defect with its skin surface turned inward (Fig. 149 *b*), and Thiersch's skin-grafts were immediately applied to the wound surfaces of the flap and the defect. The flap may be taken either from the region of the lower jaw or the temple.

Bardenheuer recommends covering defects of the cheek in cases of cicatricial lockjaw, microstoma, etc., with a flap taken from the skin of the forehead and a second from that of the neck.

For plastic operations on the nose (rhinoplasty) the reader is referred to § 42 (Surgery of the Nose), and for plastic operations on the ear (otoplasty) to § 72 (Surgery of the Ear).

§ 34. **Facial Neuralgia.**—Facial neuralgia in the distribution of the trigeminal nerve is one of the most frequent neuroses. By neuralgia

(from *νεῦρον* and *ἄλγος*) is understood an affection of the sensory nerves, whose chief symptom is pain.

The symptoms of facial neuralgia consist of pain which is either constant or, more frequently, comes in paroxysms of varying intensity. The pain is usually confined to a single branch of the fifth nerve, but it may be present over the entire region supplied by it. The pain sometimes radiates into other nerve tracts, and is not infrequently combined with clonic spasms of the motor nerves, especially the branches of the facial. The paroxysms of pain are often called forth by the slightest irritation, such as touch, pressure, a draught of air, mastication, emotion, etc. The duration and intensity of the attacks of pain are very variable. The condition of the patient is usually very pitiable; every pleasure in life is interfered with, and if the malady continues long, nutrition becomes more and more impaired, because every movement of the jaws during mastication not infrequently gives rise to a paroxysm of pain, so that the patient dreads opening his mouth.

The causes of neuralgia of the face are in part central and in part peripheral. The peripheral causes consist especially in inflammation, usually of some branch of the trigeminal nerve or its sheath during its passage through a foramen or canal in the bone. It is sometimes due to pressure upon the nerves, caused by an exudation, for example, or an exostosis. Very varied diseases of the soft parts and the bones of the face may occasion neuralgia. Empyema of the frontal sinus, for instance, not infrequently causes neuralgia of the supraorbital nerve.

Usually, however, no cause for neuralgia can be established. The patient frequently asserts that his trouble is connected with a cold taken on a definite day. Taking cold plays, at all events, an important part among the peripheral causes, but it is difficult to say in what way. This rheumatic neuralgia, however, is, as a matter of fact, rather common.

A great deal of neuralgia of the face has a reflex origin, conditioned upon some irregularity in a remote part of the body. One must keep this fact well in mind, for it is of the greatest importance in treating this affection. To these reflex forms belongs the facial neuralgia occurring in connection with chlorosis, hysteria, malaria, emotional excitement, constipation, etc. Well-marked cases of reflex neuralgia of the fifth nerve due to constipation have been reported, especially by Gussenbauer. Nussbaum has properly emphasized the occurrence of facial neuralgia in connection with dysmenorrhœa, with stenosis of the os uteri, and with diseases of the female sexual organs in general.

The central causes of neuralgia of the face are mainly the presence of tumours and syphilitic diseases of the brain and its membranes, and other diseases of the central nervous system.

As regards treatment, it is important, above all, to determine the cause of the neuralgia and its location in a definite nerve tract.

Only peripheral neuralgia in the course of a definite branch of the fifth nerve is adapted to operative treatment. The reflex forms of neuralgia are often very satisfactory cases, from a therapeutic standpoint, as they disappear immediately and permanently upon the removal of the known cause. Neuralgia resulting from central causes is of course the most unfavourable form for treatment. It is usually incurable. The decision whether, in a given case, we have to do with central or peripheral neuralgia is often impossible. Cerebral symptoms indicate the presence of a central cause, though they are often absent. The participation of other nerves in the disease is likewise an indication of a central cause, as well as the circumstance that not the entire nerve trunk but only certain branches are affected. One should always carefully examine patients with facial neuralgia to see whether there may not be some reflex cause—e. g., anæmia, constipation, disturbances of the genito-urinary organs, etc. The way in which the trouble began often affords suggestions regarding the cause of the disease. For the location of the neuralgia the presence of one or several points at which pain is felt, especially on pressure, is important.

The Treatment of Facial Neuralgia depends chiefly, in accordance with what has been said, upon the underlying cause. In case of reflex neuralgia the cause is first of all to be overcome—e. g., any existing anæmia, chlorosis, constipation, or disturbances of the genito-urinary organs, especially among women, such as stenosis of the os uteri or displacement of the uterus. If there are evidences of malaria, quinine is given. In anæmia and chlorosis preparations of iron and especially good nourishment have an excellent effect, and change of climate and residence in southern districts are sometimes strongly to be recommended.

If the cause is a central one, an effective treatment is often altogether impossible. In syphilis a permanent cure is frequently accomplished by means of an antisyphilitic treatment (inunctions, iodide of potassium).

Numerous remedies for neuralgia have been given internally. Of late antipyrine, antifebrine, phenacetine, and analgene (Dr. Vis gives half a gram six times a day) have been especially recommended. The most effectual remedy for the torment of the poor patient is a hypodermic injection of morphine.

As has been said, neuralgia resulting from peripheral disturbances in the course of the involved branch of the fifth nerve is best adapted for operative treatment. If a definite cause for the trouble, such as an exostosis or a diseased tooth, can be found, this should be removed. The principal remedy in peripheral neuralgia is division or, better, excision, complete extirpation or extraction of the diseased nerve, in order thus to interrupt the conduction from the focus of disease to the brain. Division of the nerve (neurotomy) must always be combined with the excision of as large a piece as possible from the continuity of the nerve trunk (neurectomy), in order to prevent the divided nerve stumps from growing together again. Still more effective is the extraction of the entire diseased nerve trunk together with its peripheral branches by the use of an artery clamp or, better, Thiersch's forceps. This method has been especially recommended of late by Thiersch. The forceps alluded to consists of a concave and a convex branch which exactly fit into one another (Fig. 150). I have likewise used this method repeatedly with the best results. Stretching the nerve has also been recommended, either alone or combined with its division. A definite judgment can not as yet be pronounced upon the therapeutic value of stretching the nerve in cases of neuralgia. In neuralgia of the sciatic nerve, stretching, as we shall see, is of decided value, but I have seen no good results from its use alone in facial neuralgia. The way in which nerve stretching produces its effect has not yet been made sufficiently clear. It causes a traumatic neuritis and changes in some way the relations of the nerve sheath to the nerve and to the immediate surroundings. Nerve stretching might, no doubt, be very useful in a case where the object was to free from its incarceration a nerve that was embedded, for example, in cicatricial tissue and not directly accessible for neurectomy, or to free the adherent nerve sheath, or, finally, by traction upon the nerve, to bring about changes in circulation in the same and thereby to influence the conduction and nutrition of the involved nerve trunk. Nerve stretching alone is not adapted for neuralgia of the face, but it is well, after division of the nerve, to stretch both nerve stumps by means of an artery clamp, for instance, or Thiersch's forceps (Fig. 150). Stretching the facial nerve has, however, cured trifacial neuralgia, especially when

Fig. 150.—Forceps for the extraction of nerves (Thiersch).

combined with facial spasm. The results following neurectomy are not especially favourable, as recurrences very frequently ensue. A. Wagner estimates the number of cures at thirty-two per cent. The statistics, however, are not very reliable, as the cases are often not observed for a sufficient length of time. At first neurectomy seems to be completely successful, but frequently, after some weeks or months, or even after years, recurrences take place in spite of the fact that the nerve stumps have not reunited. Such recurrences are to be explained chiefly by the existence of numerous anastomoses between the sensory nerves of the face one with another and with those of the opposite side. It is thus clear that after neurectomy a connection is very easily re-established between the peripheral diseased area and the brain by means of conduction along collateral intact nerve tracts upon the side operated upon as well as upon the other. Recurrences in consequence of reunion of the resected nerve stumps are, in my opinion, very rare. Not infrequently the operation has no effect whatever. In such cases there is probably almost always a central cause for the neuralgia. After all, one need not be surprised that one of our famous forefathers in surgery, Dieffenbach, pronounced a very positive judgment against the value of neurectomy in cases of facial neuralgia.

Whether recurrences are more rare or do not occur at all after extraction of the entire diseased peripheral nerve trunk can only be determined after this method has been used in a larger number of cases. In one case after extraction of the second branch of the fifth nerve I saw a recurrence after some months.

The technique of neurectomy of the three branches of the fifth nerve is as follows:

I. **Neurectomy of the Supraorbital Nerve.**—*Topography.*—The following brief statement should be made regarding the topography of the supraorbital nerve: The first division of the fifth nerve or ophthalmic passes, as is well known, through the sphenoidal fissure into the orbit, and here or shortly before divides into three branches—the supraorbital, the naso-ciliary, and the lachrymal nerves. The supraorbital nerve passes directly forward, the naso-ciliary nerve along the median, and the lachrymal nerve along the lateral wall of the orbit. The position of the supraorbital nerve is here of special importance for us because neurectomy is performed on it almost exclusively. The supraorbital nerve runs beneath the periosteum of the roof of the orbit and upon the levator palpebræ muscle directly forward to the supraorbital incisure, giving off upon the way two branches in a median direction: First, the supratrochlear nerve, which leaves the orbital cavity above the pulley of the superior oblique muscle and supplies the skin of the upper eyelid and the forehead; second, the frontal nerve running with the frontal artery through the incisure of the same name to the forehead. The remainder of the trunk of the supraorbital nerve turns upward at the supraorbital incisure, passes

over the supraorbital border, and runs through the canal of the same name to the region of the forehead. The description of the branches of the supraorbital nerve is given differently by different anatomists. The above is the one given by Henle.

The supraorbital nerve (see Fig. 151, 1) is exposed by means of an incision parallel to the border of the orbit just below the eyebrow, extending outward from the supraorbital incisure, which is easily felt. A perpendicular incision from the supraorbital incisure upward is not so advisable. The nerve is, to be sure, very easily found by means of the latter incision. If, after dividing the skin and the orbicularis palpebrarum muscle, the incisure is exposed, the nerve can be extracted here by means of an artery clamp. For exposing the nerve farther back in the orbit, which is a better plan, the above-mentioned transverse incision is to be recommended. The orbicularis muscle and the superior tarso-orbital fascia are divided upon a grooved director. The bulb and the levator palpebræ muscle are then carefully retracted downward from the roof of the orbit with a flat instrument, and one can now draw the tense nerve forward with a small forceps and sever it or seize it with an artery clamp, roll it up, and tear it out. Mosetig-Moorhof has also resected with success the naso-ciliary nerve close to the ethmoidal foramen for neuralgia by lengthening the transverse incision on the border of the orbit as far as the inner border of the lid and pressing the bulb outward.

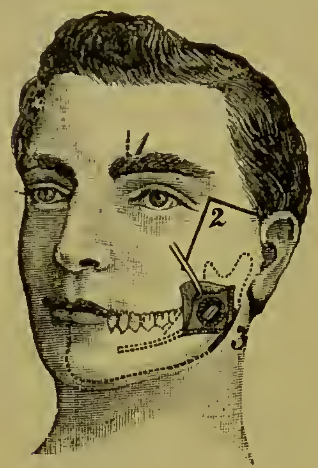


Fig. 151.—Neurectomies of the branches of the fifth nerve: 1. Neurectomy of the supraorbital. 2. Neurectomy of the superior maxillary with osteoplastic resection of the malar bone. 3. Neurectomy of the inferior maxillary.

Nicoladoni resected the ethmoidal nerve, one of the two terminal branches of the naso-ciliary nerve, in the following manner, after Zeissl: Beginning a short distance to the inner side of the supraorbital foramen, a curved incision is made close to the border of the orbit encircling the inner canthus of the eye nearly as far as the infraorbital foramen. After dividing the soft parts, the periosteum of the orbit is raised with a broad elevator and the bulb is pushed outward, whereby the lachrymal sac is pressed out of its niche, and the ethmoidal nerve is put on a stretch so that it can be easily divided. An unpleasant feature attending this is the hæmorrhage from the ethmoidal artery, which can not be protected. It is therefore better to divide the nerve close to the periosteum of the orbit and to cauterize the inner wall of

the orbit with the thermo-cautery. Displacement of the trochlear nerve is to be avoided, as otherwise diplopia results.

II. **Neurectomy of the Superior Maxillary Nerve and its Branches.**—*Topography.*—The superior maxillary nerve, the second branch of the fifth, leaves the cranial cavity through the foramen rotundum, then enters the spheno-maxillary fossa and passes from here, giving off smaller branches, through the spheno-maxillary fissure into the orbit, to run as infraorbital nerve in the infraorbital canal with the artery of the same name to the anterior surface of the face. After leaving the infraorbital canal, the filaments of the infraorbital nerve spread out in the shape of a claw, forming the pes anserinus minor in the canine fossa beneath the levator labii superioris muscle.

Neurectomy of the infraorbital nerve should be performed as near its origin as possible, best of all in the neighbourhood of the foramen rotundum at the base of the skull. Exposure of the nerve by means of a curved incision just below the infraorbital border is to be rejected as insufficient. The subcutaneous division of the nerve by means of a tenotome pushed forward along the outer wall of the orbit, with extraction of the divided nerve through the infraorbital foramen, after Langenbeck, Hueter, and Carnochan, is also impractical. Resection of the nerve in the spheno-maxillary fossa, after tunnelling the antrum of Highmore from the cheek, is just as little to be recommended. A. Wagner exposed the nerve at the infraorbital foramen by means of a curved incision along the lower border of the orbit, then laid bare the floor of the orbit subperiosteally as far as the spheno-maxillary fissure, opened the posterior portion of the infraorbital canal by means of a small chisel, raised the nerve out of the canal with a tenaculum, so as to isolate it from the artery, and severed it with curved scissors before its entrance into the spheno-maxillary fissure. The end of the nerve that has been cut off is then drawn out through the infraorbital canal from in front, and in this way completely removed.

The extraction of the infraorbital nerve can be accomplished in a simpler manner, after Thiersch, by making a transverse incision along the lower border of the orbit, exposing the terminal branches of the nerve. The inferior tarsal membrane is then detatched close to the lower border of the orbit, the infraorbital canal chiselled open by means of a narrow chisel, and the nerve raised and rolled up by means of an artery clamp or Thiersch's forceps, so that it tears out proximally and distally, even to its very finest ramifications. During this procedure one sees, by the characteristic play of the features about the upper lip, that the fine peripheral branches of the nerve are also more or less completely extracted.

Neurectomy of the superior maxillary nerve at the foramen rotundum, with osteoplastic resection of the malar bone, after Lücke or, better, after Braun and Lossen, is a very excellent method. I have performed this repeatedly with the best results. Lücke displaces the resected malar bone upward; Braun and Lossen, on the other hand, downward. By both methods an angular incision is made. Braun and Lossen make it as in Fig. 151, 2. Lücke carries the same oblique incision from above downward, but the horizontal incision runs from the lower end of this to a point a finger's breadth in front of the tragus. One disadvantage of Lücke's method consists in the fact that the masseter is detached from the malar bone by the lower horizontal incision, whereas by the Braun-Lossen method this muscle remains intact. For this reason the latter method is to be preferred. Aside from this the two methods are the same. The Braun-Lossen method is as follows:

The skin incision has the angular form represented in Fig. 151, 2. The oblique incision downward begins about one centimetre above the outer canthus of the eye, and two or three millimetres distant from the outer orbital border, and divides the soft parts and the periosteum as far as the lower border of the zygoma corresponding to the third upper molar. The soft parts on the posterior surface of the malar bone are severed with a narrow, pointed knife, and the bone is then divided with a metacarpal saw, or a chain saw, from within forward and outward in an oblique direction. The horizontal incision is then made, which begins at right angles with the upper end of the oblique incision and runs along the malar bone as far as the zygomatic process of the temporal bone. It divides the skin, subcutaneous cellular tissue, and temporal fascia. The zygoma is then broken in at its posterior part and the malar bone pulled downward. The anterior border of the temporal muscle is now retracted backward, somewhat incised, if necessary, and the adipose tissue of the spheno-maxillary fossa, and with it the internal maxillary artery and the numerous plexuses of veins, are likewise pushed backward. After the remaining adipose tissue in the depth of the wound has been carefully removed, search is made with a probe for the spheno-maxillary fissure, and here one finds the infraorbital nerve, which runs from within outward or obliquely forward and downward, while the infraorbital artery joins the nerve from the outer side. The nerve is now isolated by means of a strabismus hook, drawn forward and severed at the foramen rotundum. One can then from the oblique incision expose the terminal branches of the nerve at the infraorbital foramen and extract them with an artery clamp. It is also important to be sure that the superior alveolar nerve, running along the maxillary

tuberosity, is divided at the same time. If the nerve is not visible, Lücke recommends that the periosteum of the posterior surface of the superior maxilla be scarified and scraped away or a thin layer of bone chiselled out.

The zygoma is finally restored to its normal position and secured by suture of the bone or the periosteum with catgut or silkworm gut. The most dependent part of the wound is drained, and the latter is closed by suture. In all five cases in which I have operated in this way, bony union of the divided zygoma ensued, and there was no disfigurement.

For the method of Krönlein, see page 251.

According to the investigations of Graefe, neurectomy of the temporo-malar might be recommended as a substitute for stretching the facial nerve in facial spasm. Graefe has shown that, in consequence of stimulation of this nerve, reflex facial spasm arises, which ceases upon pressure on the nerve. The latter is found, according to Mosetig-Moorhof, by means of an incision down to the bone along the outer border of the orbit below the ligament of the outer canthus. One here comes upon the opening of the zygomatico-orbital canal in the orbital surface of the malar bone, into which the small nerve enters, and one can follow it, if desired, to its entrance into the orbit through the spheno-maxillary fissure.

III. **Neurectomy of the Inferior Maxillary Nerve and its Branches.**—*Topography.*—The inferior maxillary nerve, the third division of the trigeminal, is composed of sensory and motor fibres. After leaving the cranial cavity through the foramen ovale, the nerve divides immediately into branches, which run in different directions. From the sensory root alone originates in the foramen ovale, or immediately below it, a small branch which returns into the cranial cavity (nervus recurrens inframaxillaris). The otic ganglion is united by short filaments with the median surface of the trunk above its division. The trunk then divides into motor and into purely or chiefly sensory branches. To the motor branches belong the nerves for the muscles of mastication and the tensor palati (deep temporal, masseteric, external and internal pterygoid). Of the sensory branches, which exceed the motor in size, the auriculo-temporal nerve passes upward around the articular process of the lower jaw in front of the ear. For neurectomy, the two sensory branches come especially under consideration—the lingual and the inferior dental. Both pass downward and forward between the internal pterygoid muscle and the inner surface of the ramus of the lower jaw. The lingual nerve then runs to the floor of the mouth. The inferior dental nerve enters with the artery of the same name the dental canal of the lower jaw, to emerge as mental nerve from the mental foramen beneath the depressor anguli oris muscle. At the point of entrance of the inferior dental nerve into the dental canal there is a small, sharp projection of bone which can be easily felt in exposing the nerve—the lingula. The inferior dental nerve also contains motor fibres, which leave it at the inner surface of the jaw before its entrance into the dental canal and form the mylo-hyoid nerve, supplying the muscle of the same name and the anterior belly of the digastric. A

fourth sensory branch of the inferior maxillary nerve is the buccinator nerve, which passes between the two portions of the external pterygoid muscle, or through its upper portion, first laterally, and then forward upon the outer surface of the buccinator muscle to the cheek and the upper lip.

Of the branches of the inferior maxillary nerve that have been mentioned, the inferior dental and lingual nerves, and in rare cases also the buccinator nerve, come especially under consideration for neurectomy. The most serviceable way in case of neuralgia, in the distribution of the third branch of the fifth nerve, is to expose the nerve at the base of the skull, at the foramen ovale, and here to divide it or tear it out as completely as possible.

Neurectomy of the inferior dental nerve can be performed at three places: 1. Before its entrance into the dental canal of the lower jaw. 2. During its course in the dental canal. 3. At its point of exit at the mental foramen.

The exposure of the nerve before its entrance into the dental canal is most to be recommended. It is best accomplished by the Lücke-Sonnenburg method. A longitudinal incision is made three or four centimetres in length through the soft parts and periosteum along the posterior border of the angle of the jaw (Fig. 151, 3), with the head of the patient hanging over backward. The incision should have the same length on the ramus and body of the jaw—that is, should extend equally upward and downward from the angle of the jaw. After dividing the periosteum the latter is detached, together with the insertion of the internal pterygoid muscle, upward and backward from the inner surface of the jaw by means of an elevator until one feels the lingula distinctly. It may be necessary to detach the insertion of the internal pterygoid muscle with a blunt bistoury. A strabismus hook is then carried beyond the lingula, and, with the guidance of the finger, the nerve can be easily isolated from the inferior dental artery which lies nearer to the bone, drawn outward, and seized with an artery clamp. If necessary, the lingual nerve can also be divided. The best way is to divide the nerve, and then tear out the entire peripheral portion from the dental canal by winding it upon an artery clamp. I have repeatedly used the Lücke-Sonnenburg method with good results, and can recommend it. Nicoladoni has modified this method by making an incision one and a half centimetres behind the border of the ramus of the lower jaw, beginning on a level with the lobe of the ear and then passing downward around the angle of the jaw.

Albert in one case resected the angle of the jaw, and reached the nerve in this way. Kühne and P. Bruns exposed the nerve by resect-

ing a corresponding triangular or quadrangular portion of the posterior border of the angle or ramus of the lower jaw. Gussenbauer performed temporary resection of the malar bone, and Mikulicz temporary extrabuccal resection of the lower jaw (see page 250).

The nerve has also been exposed in the dental canal after chiselling open the anterior wall of the canal by making, for example, a curved incision at the angle of the jaw and dissecting up the skin, the masseter muscle, and the periosteum in the form of a flap from the anterior wall of the jaw (see Fig. 151, 3). After the angle of the jaw has been thus laid bare subperiosteally as far as the alveolar border, without opening the oral cavity by cutting through the insertion of the mucous membrane, a piece of bone about one centimetre broad is chiselled out of the outer wall of the lower jaw and the dental canal opened. The inferior dental nerve is then visible in the latter, as a white cord, with the artery of the same name, and can be divided or completely extracted. In older people the dental canal lies somewhat nearer the upper border of the jaw. In all external incisions through the soft parts for exposing the outer surface of the ramus of the lower jaw one must proceed in such a way as not to injure the facial nerve and Steno's duct. Linhart cut through the skin in the perpendicular plane of bisection of the ramus of the jaw, divided the masseteric fascia, exposed Steno's duct, retracted it upward with the transverse facial artery, divided the fibres of the masseter in a longitudinal direction, detached the periosteum likewise longitudinally with an elevator, and then opened the inferior dental canal with hammer and chisel. This method is to be recommended, because the insertion of the masseter at the angle of the jaw is spared.

Exposure of the mental nerve at its point of exit at the mental foramen is not suited for neurectomy, but rather for stretching the nerve. The operation may be done from within or outside the mouth. By the former method the corner of the mouth is drawn strongly downward and outward, the mucous membrane is incised in a horizontal direction corresponding to the two lower bicuspids at about the middle of one half of the lower jaw, the soft parts of the lower edge of the wound are pushed downward with a small periosteal elevator, and the mental foramen is thus exposed. The mental nerve then becomes visible, and can be isolated, divided, or partially extracted proximally and distally.

It is better to expose the mental nerve at the mental foramen by the external method, making an external horizontal incision through the soft parts. The incision begins in the region of the canine or the first lower bicuspid and ends in front of the border of the masseter,

so as to spare the facial artery. After detaching the periosteum and laying free the mental foramen, one can easily chisel open the dental canal to any desired extent. One may also make an angular incision, after Monod, by first cutting parallel to the lower border of the jaw from the median line of the chin to the anterior border of the masseter, and then adding a shorter vertical incision at the anterior end of this one and raising the soft parts in the form of a triangular flap.

The exposure of the inferior dental nerve at the lingula from within the mouth, after Lizars and Paravicini, is scarcely to be recommended. In thin persons the lingula can be felt from within the mouth on the inner surface of the ramus of the lower jaw. Lizars and Paravicini divide the mucous membrane and the periosteum by a vertical incision, about two centimetres long, on the inner surface of the ramus of the lower jaw close behind its anterior border, while the mouth is opened wide and the corner of the mouth is drawn outward. This incision should begin a little below the apex of the coronoid process and extend to a point on a level with the last molar. After elevating the muco-periosteal covering and the insertion of the internal pterygoid muscle as far as the lingula, one can expose the nerve before its entrance into the dental canal. Here also one must avoid injury to the inferior dental artery which lies somewhat above and behind, close to the bone, on account of which it has even been necessary to tie the external carotid.

Neurectomy of the Inferior Maxillary Nerve at the Base of the Skull.—Credé exposed the third branch of the fifth nerve at the foramen ovale by forming an osteoplastic flap from the malar bone in much the same way as in neurectomy of the second branch of the fifth nerve after Lücke (see page 246). This flap is then drawn downward, and one now reaches without difficulty the foramen ovale, and can easily divide or extract the nerve, after the temporal muscle has been retracted sufficiently backward.

Mikulicz's method is very practical, which consists in exposing the foramen ovale by resection of the lower jaw from the outside. Madelung has modified this method somewhat. He makes an incision through the skin from the corner of the mouth to a point two centimetres in front of the border of the inferior maxilla. The mucous membrane remains intact. The periosteum and mucous membrane are detached from the body of the lower jaw near its angle. The masseter is not separated. The lower jaw is sawn through from behind forward, or chiselled in part, in order to draw the peripheral portion of the inferior dental nerve out of the canal. The lingual nerve is put on the stretch by means of a tenaculum, and one easily passes along this nerve (with retraction outward of the condyle of the jaw, and after partial separation of the pterygoid muscle) until one reaches the junction of the lingual nerve with the inferior dental nerve, and farther on the foramen ovale. By traction on the nerve beyond the lingula it becomes visible in its entire course.

Krönlein has made the following modification of the methods of Lücke, Braun-Lossen and Pancoast for neurectomy of the second and third branches of the fifth nerve at the foramen rotundum and the foramen ovale. The operation has six steps:

1. The formation of a large semicircular flap of skin in the region of the temple and the cheek, which is to be turned upward (Fig. 152 *a b*). Its base lies above, between the outer orbital border and the tragus, and an imaginary line drawn from the nostril of that side to the lobe of the ear is tangential to its convexity. The flap is turned upward and secured.

2. The temporal fascia is detached from the entire upper border of the zygoma, and the latter is sawn through in front and behind, so that, together with the masseter muscle, it may be pulled downward as far as the skin wound allows.

3. The coronoid process of the lower jaw is exposed and chiselled through at its base in a line which runs from the deepest point of the sigmoid notch, obliquely downward and forward to the beginning of the external oblique line. The detached coronoid process is retracted upward with the temporal muscle.

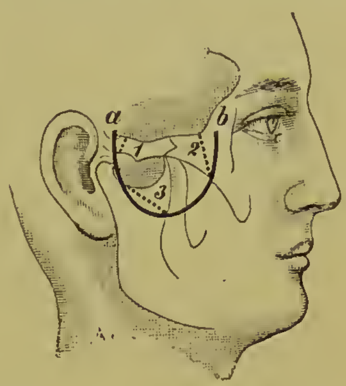


Fig. 152.—Division of the second and third branches of the fifth nerve (Krönlein): *a b*, skin incision; *1*, *2*, and *3* lines of division of the bone.

4. The internal maxillary artery is ligated between the borders of the two pterygoid muscles. The upper head of the external pterygoid muscle is bluntly detached from its origin. The inferior maxillary nerve which can now be reached is resected at the foramen ovale.

5. One now works his way forward to the foramen rotundum through the pterygo-maxillary fissure, and the second branch is resected at its exit from the foramen rotundum.

6. The individual parts are then brought back into their normal places and secured. Drainage and careful suture of the skin flap follow.

F. Krause, in a case of severe neuralgia of the fifth nerve which recurred in spite of neurectomy twice performed, exposed the nerve within the cranial cavity in the following manner and resected it with good results: The cranial cavity is opened by forming a flap of skin, muscle, periosteum, and bone, after Wagner, with its base below in the region of the temporal muscle, so that the middle cranial fossa is opened. The dura mater is carefully detached from the base of the skull, whereupon one passes by the foramen spinosum with the middle meningeal artery, and reaches the foramen rotundum with the second branch of the fifth nerve. The resection of the nerve is rendered difficult by the hæmorrhage attending the detachment of the dura. Krause therefore packed the wound cavity with iodoform gauze after exposing the nerve. The dressing was removed after five days under an anæsthetic, and the second branch of the fifth nerve was caught with a strabismus hook and resected. The patient was permanently cured. If it is desired to expose the third branch also in this way or the Gasserian ganglion, one must tie the middle meningeal artery in two places and divide it. The third branch can then be easily reached at the foramen ovale.

Salzer recommends the following method for the resection of the third branch of the fifth nerve at the foramen ovale: He makes a curved incision with its convexity upward from one end of the zygomatic arch to the other through the skin, the fascia, the periosteum, and the temporal muscle. After

temporary resection of the zygoma, the temporal muscle is detached from the skull so that the flap of skin, muscle, and bone can be drawn downward. One now exposes, by blunt dissection, the third branch of the fifth nerve and the middle meningeal artery. The coronoid process is not in the way if the mouth of the patient is moderately opened. The vessels within the pterygoid fossa lie below the surface of the field of operation and are protected from injury by the upper border of the external pterygoid muscle. Ullmann uses the following method: A curved incision is made from the lower border of the parotid gland about one and a half centimetres above the angle of the jaw to a point beyond the facial artery in such a way that the ends of the incision lie upon the border of the lower jaw, while the convexity lies two millimetres below the jaw. In this way only the lowest branch of the facial nerve is divided, the remaining branches being saved. The lower part of the parotid gland is bluntly detached from the parotid-masseteric fascia, and the gland is pulled upward. The external pterygoid muscle is separated with the scissors from the inner surface of the angle of the lower jaw. The lingula is then felt for, a thread passed about the inferior dental nerve, and the latter divided at the inferior dental foramen. The nerve now serves as a guide for reaching the foramen ovale. The lingual nerve with the chorda tympani can easily be seen (as in the method of Sonnenburg-Lücke), and the middle meningeal artery lies on the outer side of the inferior dental nerve. The lingual nerve is divided at a point proximal to the chorda tympani. In the case of persons with a strongly projecting angle of the jaw this may be temporarily or completely resected.

Krönlein recommends the following method for exposing the third branch of the fifth nerve: A linear incision is made through the skin and the subcutaneous cellular tissue from a point one centimetre from the corner of the mouth to a point one centimetre in front of the tip of the auricle. The buccinator muscle and the mucous membrane remain intact. The masseter muscle is partly divided from in front backward (about two thirds). and the parotid gland, and Steno's duct, which is higher up, remain uninjured. The base of the coronoid process is exposed, divided with bone-cutting forceps, and drawn upward with the temporal muscle by means of a sharp hook. The mass of fat in the cheek and the deep layer of fat upon the lateral border of the internal pterygoid muscle are bluntly detached (the buccinator nerve which runs downward and forward over this mass of fat is to be looked out for). The lingula is felt for and the inferior dental and lingual nerves are isolated. The chorda tympani and the internal maxillary artery are also easily visible if the nerves are carefully isolated. In order to follow the nerves still farther on to the foramen ovale, and to find the auriculo-temporal nerve, one must retract the external pterygoid muscle strongly upward or tear through its fibres. The internal maxillary artery is to be tied, if necessary, and divided. One now sees the auriculo-temporal nerve behind the others surrounding with its branches the middle meningeal artery. At the close of the operation the coronoid process is secured in its original location, the masseter is stitched together, and drainage and suture follow.

Neurectomy of the Lingual Nerve may be performed, as has been mentioned, from the angle of the jaw, after Lücke-Sonnenburg, with

simultaneous resection, it may be, of the inferior dental nerve (see page 250). One can also expose the nerve, after Löbker, by means of a curved incision along the anterior lower border of the masseter muscle. After the anterior border of the ramus is laid free, a longitudinal piece is chiselled out from this border of bone, whereby the lingual nerve becomes visible on the outer surface of the internal pterygoid muscle. Luschka proposed exposing the nerve from the sublingual region by an external incision. After division of the skin, the platysma, and the fascia from the chin to the edge of the masseter along the lower border of the jaw, the submaxillary gland is drawn forward and downward, as well as the submental artery and vein and the mylo-hyoid nerve after dividing the deep layer of the fascia upon the mylo-hyoid muscle. After the border of the latter has been drawn forward or incised, one can easily expose the nerve on the lower border of the sublingual gland, which now becomes visible, and follow it a long way in a proximal direction. For the methods of Krönlein and Salzer, see pages 250, 251.

Neuralgia of the buccinator nerve is less common. It is especially characterized by pain in the mucous membrane of the cheek and in the skin and mucous membrane of the corner of the mouth and the lips. Pain running out beyond these points may be considered, in case of disease of this nerve alone, as only radiating pain. According to Holl, one finds the buccinator nerve with ease from within the mouth on the inner surface of the tendon of the temporal muscle near its insertion on the coronoid process, because the nerve is covered here only by mucous membrane and a little adipose tissue. One should therefore, according to Holl, make an incision above the last molar on the outer border of the depression which is found, when the mouth is opened wide, in the posterior and outer part of the oral cavity. The edge of the knife should be directed against the coronoid process. After dividing the mucous membrane, one comes immediately upon the buccinator nerve and can easily isolate it from the adipose tissue. Zuckerkandl recommends exposing the main trunk of the nerve from the outside, and at the same place at which Holl exposes it from within the mouth. This method of Zuckerkandl's is, at all events, easier than Holl's, and, moreover, makes a more complete antiseptic treatment possible.

The various steps of Zuckerkandl's operation are as follows:

1. A transverse incision is made five centimetres in length through the skin of the cheek, a finger's breadth below the zygoma, in the direction from the tragus to the middle of the naso-labial furrow.

2. The fascia covering Steno's duct is divided, whereby the same is laid free, together with its accompanying nerves.

3. Steno's duct and its accompanying nerves are displaced downward as far as possible (or upward, it may be) and retained in this position.

4. The mass of fat in the bucco-temporal fossa which now lies exposed is easily removed.

5. The main trunk of the buccinator nerve is seized at the point where it

adjoins the insertion of the temporal muscle (about two and a half or three centimetres behind the anterior border of the masseter), is drawn out and divided.

In obstinate cases of trifacial neuralgia that recur there remains nothing but intracranial neurectomy of the trigeminus trunk or removal of the Gasserian ganglion and the peripheral trigeminal branches (Fig. 153). This operation has been successfully performed by Horsley, Keen, Hartley, Krause, Finney, and others. Rose exposed the ganglion by resecting the superior maxilla and trephining the base of the skull in the vicinity of the pterygoid process. The middle meningeal artery can scarcely remain uninjured (Fig. 153), and the internal carotid is in danger. Krause's method, as described on page 251, is preferable—i. e., the cranial cavity is opened in the temporal region by the formation of a flap of skin, soft parts, and bone, with its base at the zygoma. In order to shorten the operation, Krause has of late cut a flap in the temporal region consisting of skin and periosteum, and then chiselled a small hole in the bone which he quickly enlarged to the proper size with rongeur forceps. After opening the skull, the brain, together with the uninjured dura, is raised with broad retractors, the middle meningeal artery, which is usually situated in front of the third division, is cut between two ligatures, and the trigeminal trunk, the ganglion, and the branches are carefully isolated from the dura and bone. The trunk of the trigeminus is divided at a point central to the ganglion (Fig. 153), and then the peripheral branches of the nerve, together with the ganglion, if possible, are torn out by means of Thiersch's forceps, and in this way removed *in toto*. As probably the anterior and superior segment of the ganglion contains the trophic fibres for the eye, nutritive disturbances have sometimes been seen to follow removal of the ganglion.

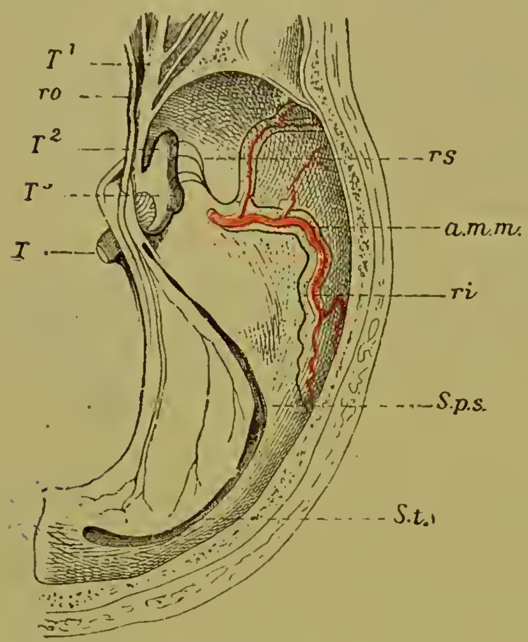


Fig. 153.—Course of the fifth nerve and location of the Gasserian ganglion within the cranial cavity: *T*, fifth nerve with the Gasserian ganglion; T^1, first, T^2, second, and T^3, third branch of the fifth nerve; *ro*, recurrent branch of the ophthalmia; *rs*, recurrent branches of the superior maxillary; *ri*, recurrent branches of the inferior maxillary; *a.m.m.*, middle meningeal artery; *S.t.*, lateral sinus; *S.p.s.*, superficial petrosal sinus (Henle).

§ 35. **Paralysis of the Facial Nerve.**—Paralysis of the facial nerve has sometimes a central and sometimes a peripheral origin. Peripheral facial paralysis arises mainly from traumatic or mechanical causes—e. g., from injury of the nerve during operations in the neighbourhood of the parotid gland, or during resection of the upper or lower jaw, from pressure of the forceps during delivery, and some-

times from a severe box on the ear. It frequently results from diseases of the petrous portion of the temporal bone (tubercular or syphilitic processes, caries), also from simple catarrh of the middle ear. The author has described this latter form of paralysis more in detail in his monograph on the subject. The so-called "rheumatic" paralyses of the facial nerve from sudden cooling off or taking cold are sometimes occasioned by acute catarrh of the middle ear. Rheumatic paralysis of the nerve resulting from rapid cooling off of the skin—e. g., in a draught—is very frequent, however, without simultaneous disease of the middle ear. Central paralysis of the facial nerve arises from cerebral lesions. For injuries of the facial nerve during its course within the cranial cavity, see § 16, page 118.

Paralysis of the facial nerve is also observed in connection with cephalic tetanus—that is, tetanus which occurs, according to Rose, Bernhardt, Güterbock, P. Klemm, and others, after injuries in the distribution of the cranial nerves—and is combined with paralysis of the facial nerve and spasm of the pharyngeal muscles, as in hydrophobia (hence also called hydrophobic tetanus). Paralysis of the facial nerve is due, according to Rose, to incarceration of the swollen nerve in the Fallopian canal, which has not always been demonstrated, however, at the autopsy. According to Brunner, this is founded upon a mistake in observation (see also page 202).

The symptoms of paralysis of the facial nerve are very characteristic. For a more detailed description of them, the reader must be referred to treatises upon nervous diseases. In case of bilateral paralysis, the face loses all expression and may be compared to a rigid mask. In unilateral paralysis the face is drawn over toward the sound side, the eye on the affected side can not be closed, winking is impossible, tears run down the cheek, and the conjunctiva of the bulb is reddened and more or less inflamed. Spitting, blowing, and whistling are no longer possible, the pronunciation of the labial consonants is interfered with, and the corner of the mouth droops. The behaviour of the uvula is very variable. The sense of smell is usually interfered with, and that of hearing is disturbed, partly in consequence of simultaneous catarrh of the middle ear and partly because the auditory nerve may be drawn into sympathy by the same cause. There is sometimes increased power of hearing in consequence of the preponderance of the tensor tympani muscle which is supplied by the fifth nerve over the stapedius muscle supplied by the facial nerve. Changes in taste occur, especially when the fibers of the fifth nerve within the chorda tympani are likewise diseased or injured. The movements of the tongue are not affected.

The treatment consists mainly in the use of electricity. The anode of a constant current which is not too strong is placed in the auriculo-mastoid fossa of the diseased side and the cathode in that of the sound side, and the direction of the current is occasionally changed. The faradic current is also serviceable. Diseases of the ear must be treated in accordance with general rules (see Diseases of the Ear). In case of division of the facial nerve, neurorrhaphy is to be performed as promptly as possible.

Spasm of the Facial Nerve.—Facial spasm in consequence of irritation of the facial nerve is characterized by continuous convulsive movements of the facial muscles, especially of the orbicularis palpebrarum, with closing of the palpebral fissure (blepharospasmus). The contractions are in part reflex in consequence of increased irritability of the fifth nerve. In such cases one can immediately interrupt the spasm by pressure upon the point of exit of the oversensitive sensory branch of the fifth nerve. As the facial spasms are so often occasioned in a reflex way by the fifth nerve, one should make a careful examination in each case for disease along the distribution of that nerve. By overcoming diseases of the nasal cavity—e. g., by the use of the galvano-cautery, by removal of a hypertrophied turbinated bone, etc.—facial spasms have been completely cured. The nasal cavity is very sensitive in such cases, and even touching the mucous membrane with the probe may immediately call forth the spasms. In other cases either neurectomy or stretching the involved branches of the fifth nerve is to be recommended, or, as was said (page 247), neurectomy of the temporo-malar nerve. Facial spasm has also been repeatedly and permanently cured by massage (Abadie).

Fig. 154.—Operation for stretching the facial nerve.

If the spasms are conditioned directly upon changes in the facial nerve itself—e. g., upon disturbances in nutrition—stretching the same is indicated (Baum, C. Hueter). The nerve may be exposed for this purpose either at its exit from the stylo-mastoid foramen (Baum), or farther forward, in the tissue of the parotid gland, at the point where it crosses the posterior border of the jaw (Fig. 154).

The former method, that of Baum, is the more difficult. A semilunar incision is made around the lobe of the ear and a second perpen-

dicular incision downward one centimetre long parallel to the posterior border of the ramus of the lower jaw. By retraction of the upper border of the parotid gland, one comes immediately upon the stylo-mastoid foramen. The styloid process serves as a guide. In front of this lies the nerve covered by a small vein, and it can be easily isolated. The stretching, which is done in a proximal and distal direction, should not be undertaken with a forceps, inasmuch as pressure paralysis so easily occurs, but preferably with a strabismus hook.

Exposure of the nerve, as recommended by Löbker and Hueter, at the point where it crosses the posterior border of the jaw (Fig. 154), is much easier, as I can affirm from my own experience. An incision about five centimetres long separates the insertion of the lobe of the ear from the cheek and runs downward along the posterior border of the jaw. The fascia and tissue of the parotid gland are carefully divided, the knife being constantly directed against the border of the jaw so as not to injure the external carotid artery which runs behind it. In dividing the tissue of the parotid, one usually comes first upon the inferior branch of the facial nerve, follows it to the superior branch, and then exposes the trunk of the nerve still farther back toward the stylo-mastoid foramen. The nerve should be stretched, as has been said, in a proximal and distal direction with a strabismus hook or upon a thin India-rubber tube, in order to avoid, as far as possible, paralysis from crushing the nerve.

In order to expose the nerve more completely in the direction of the stylo mastoid foramen, one may finally, after it has been found, add an oblique incision running toward the foramen (Kaufmann).

I have stretched the facial nerve for facial spasm three times, once with permanent and once with only temporary success. In the third case permanent improvement was all that was secured. According to R. Schott, no result followed in fifty-eight per cent of the cases reported, in thirty-two per cent there was improvement, and in only ten per cent actual cure.

CHAPTER V.

INJURIES AND DISEASES OF THE NOSE AND NASAL FOSSÆ.

I. *The Nose:* Deformities of the nose.—Deviation of the nasal septum—Injuries.—Fractures of the nasal bones and cartilages.—Inflammatory processes on the nose.—Eczema.—Chronic hypertrophy, lupus, syphilis.—Partial and complete occlusion of the nostrils.—New growths of the skin of the nose.—Rhinoscleroma.

II. *The Nasal Fossæ:* Examination of the nasal fossæ and the naso-pharyngeal space (rhinoscopy, pharyngo-rhinoscopy).—Epistaxis.—Inflammations of the nasal cavity.—Acute and chronic catarrh (ozæna simplex).—Blennorrhœa.—Hay fever.—Croup.—Diphtheria.—Phlegmonous inflammations.—Lupus, syphilis, glanders, leprosy.—Foreign bodies, concretions (rhinoliths).—Parasites in the nasal cavity.—Tumours.—Opening the nasal cavity by operative means.

Plastic operations on the nose (rhinoplasty).

§ 36. **Congenital Deformities of the Nose.**—Of the congenital malformations of the nose, we have already mentioned nasal clefts, etc., when treating of clefts of the face (see § 25, page 187). In extremely rare cases absence of the nose has been observed—e. g., in cyclopia. As has been already mentioned, Maisonneuve reported such a case, in which a seven-months-old child had in the place of the nose only two nostrils one millimetre wide and three centimetres apart. The nose sometimes forms a snoutlike appendage located above the eye. Congenital occlusion of the nostrils, partial or complete, is more frequent, and, like the acquired occlusion of the nostrils caused by inflammations, such as lupus or syphilis, for instance, is treated by opening or widening the closed or contracted nostrils by a simple or a cruciform incision, and bordering the skin margins with skin or mucous membrane. The opening is then maintained by means of suitable metallic tubes or thick-walled India-rubber drainage-tubes.

Extreme congenital malformations of the nose are, as a rule, combined with other malformations of the face (see § 25). The function of the nose is then accordingly more or less interfered with. The most important function of the nose, aside from smell, consists chiefly in warming, purifying, and moistening the air that is breathed.

Deviation of the nasal septum, or of the entire nose, in consequence of abnormal processes of growth, is of special practical signifi-

cance. Welcker and Trendelenburg, in particular, have made a careful study of this abnormality. It is very common in its mild degrees. In fact, according to Klein, only two per cent of all individuals have a perfectly straight nasal septum. The convexity of the curvature lies more frequently to the right, and the right nasal fossa is therefore more or less contracted. The oblique or bent surface of the cartilaginous septum can usually be seen easily from the outside, and is sometimes mistaken by the inexperienced for mucous polyps. This obliquity of the nasal septum is, as a rule, not demonstrable before the sixth or seventh year, and it then gradually increases and reaches its limit between the seventeenth and the twentieth year. In addition to the cartilaginous nasal septum, the vomer is usually likewise deviated, and, according to Trendelenburg, A. Schaus, and Potiquet, there commonly exists asymmetry of the entire facial part of the skull in consequence of the abnormal growth, and particularly inequality of the palate processes and the posterior nares as well as diminution in the size of the entire nasal cavity. The palate process corresponding to the convexity of the curved septum is, as a rule, smaller. Trendelenburg therefore properly regards deviation of the septum as the result of a disturbance in the growth of both superior maxillary bones, in which the nasal septum does not primarily participate, but only secondarily. Rhachitis is often, perhaps, the underlying cause.

The disturbances resulting from deviation of the nasal septum consist chiefly in defective cleansing and ventilation of the involved nasal fossa in various nervous disturbances, and in interference with respiration, especially when the patient sleeps lying with his nose pressed into the pillow on the side that is not contracted.

The best treatment of a deviated nasal septum consists in the excision of the projecting part of the cartilage, after one has detached in an upward direction the mucosa and the perichondrium on the convex side with an elevator from a horizontal incision along the base of the septum (Volkmann). Petersen exposes the cartilaginous septum by detaching the mucous membrane and the perichondrium in the form of a rectangular flap with its base upward. A perforation of the septum toward the sound side is to be avoided as far as possible. Krieg and Schutter form a tongue-shaped flap of mucous membrane and perichondrium with its base behind, and then resect the projecting portion of the septum. Genzmer recommends simply cutting away the projection with a curved blunt-pointed bistoury.

Jurasz and Adams correct the deviation of the nasal septum by means of special forceps, and then introduce suitable ivory plates. In case of disfiguring congenital deviation of the entire nose, Trendelen-

burg overcomes the deformity by chiselling into the bony framework of the outer nose subcutaneously from the pyriform aperture in the direction of the inner canthus, and then forcibly bringing the nose into the right position with the hand. The deformity must be over-corrected, as the nose easily falls back into its former abnormal position. The proper position is maintained by packing the nasal cavity and applying a trusslike apparatus similar to that suggested by Adams.

§ 37. **Fractures of the Nasal Bones and Cartilages** occur frequently from direct force—e. g., a blow or a fall. The displacement of the fractured nasal bones usually takes place in the direction of the nasal cavity, and the disfigurement occasioned thereby may be very great. The degree to which the nose is flattened is very variable. In other cases the displacement is of such a kind that the dorsum of the nose deviates from the middle line. If the continuity of the mucous membrane is interrupted, an emphysema of the subcutaneous cellular tissue usually results, which is, as a rule, circumscribed.

In consequence of fracture of the cartilaginous nasal septum, a deviation of the same results, owing to its being bent at an angle, so that one nostril may be more or less completely occluded. This traumatic deviation of the septum, in consequence of fracture, is less common, however, than the deviation of the septum or the entire nose mentioned above (page 259) as resulting from abnormal processes of growth.

For fractures of the ethmoid bone, see § 9 (Fractures of the Base of the Skull).

The treatment of fractures of the bony framework of the nose consists chiefly in overcoming any displacement that may exist, by introducing a large closed dressing forceps into the nasal cavity with the right hand, and lifting up the depressed bone, while one brings the fragments into coaptation with the left hand. The fragments often maintain their corrected position of themselves, but it is usually better and sometimes necessary to pack the nose with iodoform gauze, which is also serviceable for the sake of arresting hæmorrhage. Gutta-percha splints have also been applied on the inside or the outside, which are secured by means of a needle stuck transversely through the nose, and a twisted suture applied about the needle.

The angular position of the nasal septum in consequence of fracture can be overcome by seizing the septum between the blades of a dressing forceps and straightening it. The fractured septum has also been secured by means of metallic or gutta-percha plates pushed into the nasal cavities.

It may be necessary to treat deformities of the nose resulting from badly united fractures by operative measures with the chisel, after

Trendelenburg (see page 260), E. Roberts, and others. The parts can be maintained in their corrected position by means of a needle passed through transversely. Finally, the apparatus for straightening up sunken noses may also be of service in treating fractures (see page 295).

For wounds, burns, and frostbites of the nose, see § 26, page 201.

§ 38. **Diseases of the Outer Nose.**—The inflammatory processes upon the external nose are essentially the same as those on other parts of the face, which we have already mentioned (§ 27).

Eczema, in particular, occurs about the nostrils among scrofulous children, or in consequence of nasal catarrh. It is sometimes combined with induration of the tip of the nose and the alæ nasi, or of the entire nose.

The treatment consists in applying unguentum diachylon or salicylic vaseline and powdering the parts with oxide of zinc and starch. In obstinate cases one can bring about a rapid cure by the use of the galvano-cautery.

Of chronic inflammations I mention chronic inflammatory hypertrophy, which leads to uneven, unsymmetrical lobular swellings of the nose (rhinophyma, Hebra) (see Fig. 155).

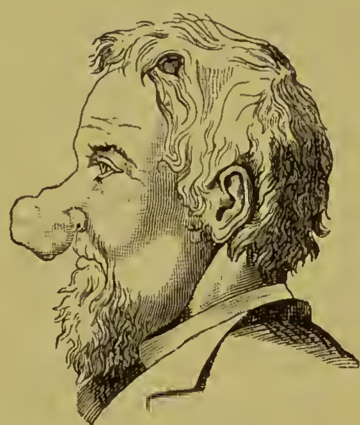


Fig. 155.—Hypertrophy of the skin of the nose (Billroth).

In this category belongs the red nose noticed among middle-aged men who are too much given to the use of alcohol (so-called gin-nose, copper-nose, Burgundy-nose). There is usually a nodular hypertrophy of the skin of the nose with dilatation of the vessels to small, distinctly visible trunks of a bluish-red colour, varying in size.

In other cases the enlargement of the nose is conditioned chiefly upon hypertrophy of the follicles, resulting from acute and subacute inflammation of the sebaceous glands, which leads secondarily to hypertrophy of the connective tissue (acne rosacea).

Hypertrophy of the nose sometimes becomes very marked. Trendelenburg mentions a case in which the nose was sixteen centimetres long and twenty-two centimetres broad.

The treatment of this chronic inflammatory hypertrophy consists, in extreme cases with very great enlargement of the nose, in wedge-shaped excisions with subsequent suture. I have also obtained satisfactory results from the injection of alcohol and the use of the galvano-caustic needle.

Lupus occurs especially on the tip of the nose and on the alæ nasi. It usually begins in the skin or mucous membrane (see page 274) and attacks the cartilage and bone secondarily. Secondary syphilis has its location more frequently in the bony portion of the nose. Clinically, lupus occurs on the nose in the same forms as on the rest of the face. I therefore refer the reader for the symptomatology and treatment of lupus of the outer nose to pages 211, 212. We shall describe more fully the change in the form of the nose produced by lupus, and the treatment of the same, when we come to treat of rhinoplasty (§ 42).

The syphilitic primary lesion occurs very rarely on the outer nose. Secondary manifestations, on the other hand, consisting in syphilitic exanthemata, ulcers, catarrh (coryza syphilitica), and especially in gummatous inflammations, which originate particularly in the periosteum and perichondrium in the form of gummatous periostitis and perichondritis, or also in the mucous membrane, are more common. These circumscribed or diffuse gummatous inflammations lead to deep-seated destruction of the soft parts, bone, and cartilage, with corresponding defects. After syphilitic destruction of the bony framework of the nose, the characteristic sunken or "saddle-nose" results.

In consequence of the necrosis of the bone, the ulcers with their muco-purulent secretion, and the hardening of the latter into dirty, dry crusts, syphilitic patients frequently emit an offensive odour (syphilitic ozæna, see pages 275, 276).

Energetic local treatment is applicable here also, such as dividing and scraping out the nose (see pages 280–282) and a suitable general antisyphilitic treatment (mercury, iodide of potassium; see Principles of Surgery, § 84). For the treatment of defects of the nose due to syphilis, see § 42 (Rhinoplasty).

Stenosis or complete occlusion of the nostrils sometimes occurs after ulcerative processes, in connection, for example, with lupus, syphilis, or small-pox. Rhinoliths (see page 277) are then formed in some cases in consequence of hardening of the secretion of the nose.

The treatment consists in dilating the contracted nostrils, or opening them, if completely closed, by means of a simple or a cruciform incision, and bordering the edges of the incision with skin or mucous membrane. The artificial opening is then maintained by means of thick-walled India-rubber drainage-tubes or metallic tubes.

Tumours of the Nose.—The tumours of the outer nose are essentially the same as those of the face that have been described more in detail (pages 213, 214 ff). Hard or soft fibromata, angeiomata (Fig. 156, after Billroth), and epitheliomata are the most common. The more diffuse

lobulated fibromata sometimes reach a very large size. Trendelenburg mentions a case reported by Theulot in which a lobulated fibroma weighing five pounds hung down over the chin. The diffuse lobulated fibroma forms the transition to diffuse hypertrophy of the skin of the nose. The treatment is the same as that of tumours of the other portions of the face, plastic measures being resorted to here also, if neeessary. Ignipuncture with the galvano-cautery is also to be recommended for angeiomata.

Fig. 156.—Arterio-venous racemose angeioma of the skin of the nose (Billroth).

Dermoid eysts of the outer nose, aecompanied sometimes by the formation of fistulæ, have been described in detail especially by Bramann. They are the result of eongenital disturbanees in the development of the nose, just as congenital fissures of the nose are.

Rhinoscleroma.—By rhinoscleroma, which was first described by Hebra in 1870, is understood a peculiar tumour-like disease, chiefly of the nose, whieh is characterized by the formation of hard nodules in the skin and mucous membrane of the nose (Fig. 157). This disease has a very chronic eourse, and is absolutely incurable. Rhinoscleroma has thus far been observed most frequently in the eastern provinces of Austria, in the southern part of Russia, and in a narrowly defined district of America.

Fig. 157.—Rhinoscleroma in a girl of sixteen (Wolkowitsch).

The disease usually begins imperceptibly in the lower parts of the nasal cavity, rarely in the pharynx and larynx or on the hard palate. The upper part of the nasal cavity, above the inferior turbinated bone, is usually free from the disease, so that the sense of smell is retained. The affection passes from the nose to the neighbouring parts of the skin (the upper lip, the lower lip, the upper jaw), the pharynx and the larynx. This course is less frequently reversed. According to Wolkowitsch, among eighty-

five cases the nose was involved eighty-one times, the outer nose seventy-four times, the pharynx fifty-seven times, the larynx nineteen times, the trachea five times, the upper lip forty-six times, the alveolar process of the upper jaw sixteen times, the hard palate seventeen times, the tongue four times, the lower lip twice, the lachrymal sac five times, and the ear once.

The symptoms of rhinoscleroma are essentially the following: With the symptoms of nasal catarrh, painless nodules as hard as cartilage, partly diffuse and partly circumscribed, are formed in the deeper layers of the skin and the mucous membrane, which spread from here beneath as well as along the surface, and finally undergo degeneration into connective tissue. In consequence of the tendency of this tissue to contract, there arise corresponding functional disturbances (narrowing and distortion of the nose, the mouth, the pharynx, the palate, etc.). Rhinoscleroma is sometimes complicated by suppuration. The disease appears in the larynx in the form of a hypertrophic inflammation of the true vocal chords. If the larynx and trachea are involved, severe and dangerous dyspnœa may ensue, but otherwise the discomfort is slight. The changes in the pharynx and the mouth give the most trouble in connection with eating and talking.

Pathologically, rhinoscleroma consists of granulation tissue—that is, of round cells and fibrous connective tissue. Mikulicz distinguishes two kinds of cells—simple, very granular ones, and large, inflated ones, similar to fat cells, which often have homogeneous contents (hyaline degeneration, vacuole formation). The micro-organisms found in the tissue of the rhinoscleroma are characteristic bacilli. They lie chiefly in the large, inflated cells (Frisch, Chiari, Cornil, Alvarez, Köbner, Eiselsberg, Nikiforow, Wolkowitsch).

Fig. 158.—Bacilli of rhinoscleroma in large hyaline cells without nuclei; section of a portion of tissue taken from the pharynx × 1,000 (C. Fraenkel and R. Pfeiffer).

According to Paltauf, Dittrich, Rydygier, Gross, and Wolkowitsch, the pure cultures of the rhinoscleroma bacilli resemble those of Friedländer's pneumonia coccus, but they can, according to Paltauf, Dittrich, Rydygier, and others, be distinguished. The cultures of the rhinoscleroma bacillus dry, for example, much more quickly, and thereby lose their power of growth. They cause no development of gas in a saccharine solution as the pneumonia cocci do. The latter grow well upon an acid nutritive medium, the former not at all or very little.

According to Alvarez, rhinoscleroma is very frequent among the people of Central and South America who are engaged in the manufacture of indigo, and the bacillus of rhinoscleroma has a marked similarity to the micro-organism concerned in the fermentation of indigo.

No success has as yet attended the effort to develop an analogous disease in animals by the inoculation of pure cultures of these bacilli, and still they are, no doubt, to be regarded as the cause of rhinoscleroma.

The treatment of the disease has thus far always been without result. Injections of antiseptic fluids have been chiefly recommended. Doutrelepont recommends inunctions of one per cent bichloride in lanoline and injections of bichloride. The latter were in some cases wholly without effect (Wölfler). In suitable cases operative interference is necessary (the galvano-cautery, caustics, the sharp spoon, tracheotomy in case of dyspnœa, cosmetic operations, etc.). Lubliner observed spontaneous cure during an attack of typhus fever.

§ 39. **Inspection of the Nasal Cavity and Naso-pharynx.** —Inspection of the nasal cavity and the naso-pharyngeal space is accomplished either from in front (anterior rhinoscopy) or from behind, through the pharynx (posterior rhinoscopy).

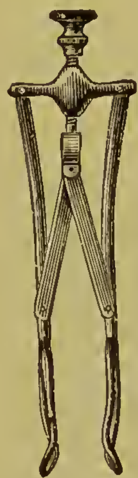


Fig. 159.—Fraenkel's nasal speculum.

Fig. 160.—Zaufal's speculum for the naso-pharynx.

Inspection of the nasal cavity from in front is accomplished by the use of an ordinary reflector after the nostrils have been as widely dilated as possible by the introduction of a nasal speculum or dilator. The nasal specula are similar to those used for the ear or rectum. A very serviceable dilator which I use exclusively is that devised by B. Fränkel (see Fig. 159). The blades of the instrument are introduced into the two nostrils to a point behind the cartilage of the alæ, so that the septum lies between, and the alæ nasi are then forced apart by turning the small screw. The instrument then keeps in place of itself without support. One may, of course, introduce both blades of the instrument into one nostril. An ordinary reflector is used in illuminating, either sunlight or lamplight being utilized for the purpose. A plain reflector is better for the sunlight and a concave reflector for lamplight. The tip of the nose is somewhat elevated with the thumb of the left hand and the head of the patient is placed in the proper position according as one wishes to examine the upper, the lower, the anterior, or the posterior part of the nasal cavity. In this way the anterior part of the cavity can be very well seen, and if the nose is roomy, one gets a view as far as the posterior wall of the pharynx and can see the Eustachian tube

and the movements of the soft palate during swallowing and speaking. Any crusts in the nose which interfere with the examination are removed by syringing.

Under certain conditions there is an advantage in performing anterior rhinoscopy with long tube-shaped instruments. The best ones of this kind are the tubes suggested by Zaufal, made of metal or hard India-rubber. They are about eleven and a half centimetres long and of varying calibre (usually five different sizes, see Fig. 160). One of these instruments of a size corresponding to that of the entrance to the nose is introduced into the lower meatus with the right hand and the tip is directed toward the inferior turbinated bone, so as not to strike against a ridge of the septum which bleeds very easily. While one carefully inspects the mucous membrane of the nose, the tube is pushed slowly ahead by slight rotatory movements as far as the posterior nares. In order to properly view the vicinity of the Eustachian tubes, one has the patient intone the letter *a* or swallow when the tip of the instrument has reached the posterior nares.

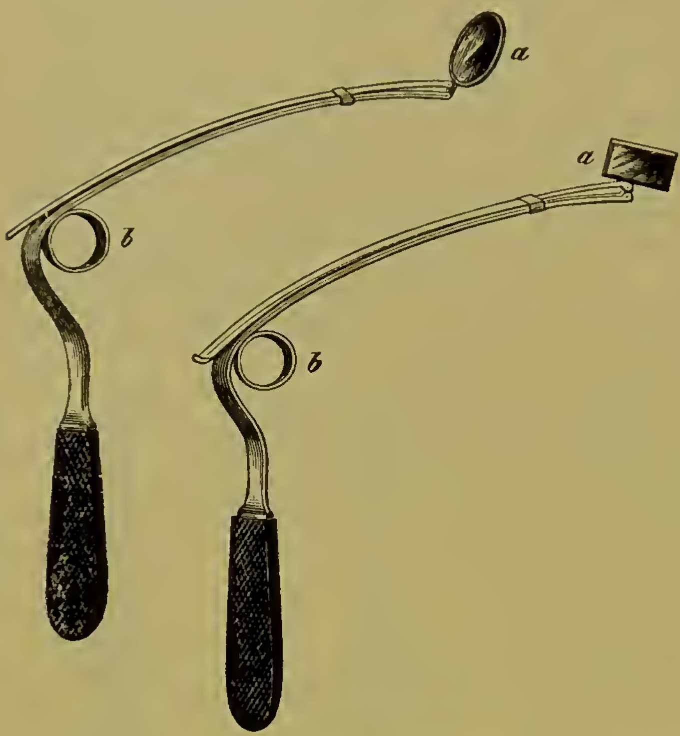


Fig. 161.—Fraenkel's rhinoscope.

Posterior rhinoscopy, which was introduced by Czermak, aims at an inspection of the naso-pharynx and the posterior portion of the nasal cavity from the pharynx. For this one needs in the first place a tongue depressor. Ash's tongue depressor (see Fig. 163) is very practical, which remains in place without being held. One may also, as in laryngoscopy, have the patient hold his extended tongue by means of a handkerchief. For illuminating the naso-pharyngeal cavity the smallest sizes of the laryngoscopic mirror are used, or the rhinoscopic mirrors constructed for this purpose together with suitable artificial or natural light (lamplight or sunlight). The rhinoscopes invented by B. Fränkel (see Fig. 161) are very serviceable, on which a round or rectangular mirror (*a*) can be moved about an axis perpendicular to the direction of the handle by pushing forward and backward a ring (*b*). The normal location of the soft palate is such as to make posterior rhinoscopy difficult or impossible, and in order to remove it from the posterior pharyngeal wall and to draw it forward numerous instruments have been construct-

Fig. 162.—Fraenkel's uvula holder.

ed, and they have been brought into direct combination with the rhinoscope (Störk, Baxt). Störk has also, by means of a Bellocq's cannula (see Fig. 167), passed a loop of thread or tape through the mouth, the pharynx, and the inferior meatus. By means of this the patient can himself draw his soft palate away from the posterior pharyngeal wall. Uvula holders are often entirely unnecessary. If needed, that of B. Fränkel (Fig. 162) or the palate retractor of Voltolini (Fig. 163) and similar instruments are to be recommended. The sensitiveness of the pharynx, which is sometimes great, can be best overcome by applying a from five- to twenty-per-cent solution of cocaine with the brush. One can then dispense with the palate retractor.

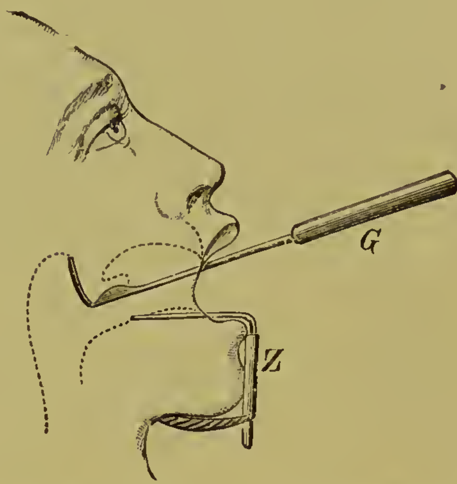


Fig. 163.—Application of Ash's tongue depressor (Z) and Voltolini's pharyngo-rhinoscope.

The technique of posterior rhinoscopy is as follows: The head of the patient is best placed in the habitual middle position—that is, it is inclined a little forward, in order that the soft palate by its weight may become separated from the pharyngeal wall. The tongue is held down by a depressor with the left hand, or one may use Ash's self-retaining depressor. Many patients can hold the depressor themselves. The above-mentioned rhinoscopic mirror is introduced near the middle line above the tongue and then carried to the right or left beneath one of the palatine arches. In introducing the mirror the mucous membrane must not be touched. By raising or lowering the mirror or by turning it to

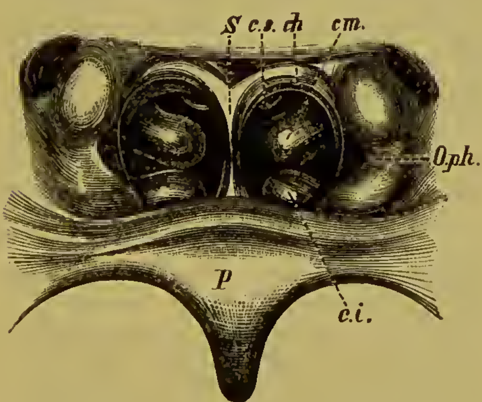


Fig. 164.—Rhinoscopic picture: *S*, septum; *c.s.*, superior turbinated bone; *ch*, posterior nares; *c.m.*, middle turbinated bone; *c.i.*, inferior turbinated bone; *O.ph.*, orifice of the Eustachian tube; *P*, soft palate (Urbantschitsch).

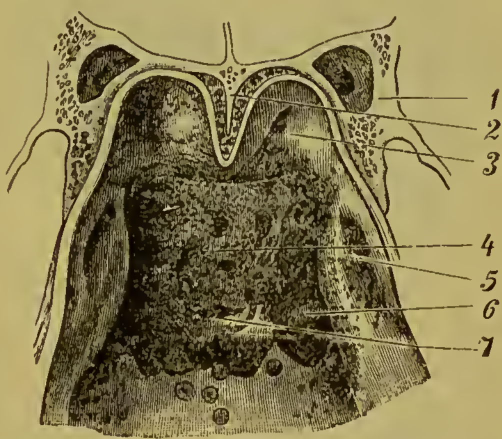


Fig. 165.—Frontal section of the naso-pharynx; *1*, pterygoid process; *2*, vomer; *3*, posterior termination of the roof of the nasal cavity; *4*, adenoid tissue of the pharyngeal tonsil; *5*, orifice of the Eustachian tube; *6*, Rosenmüller's fossa; *7*, orifice of the pharyngeal bursa (Luschka).

one side, the different parts of the naso-pharyngeal space can be examined. By intoning the letter *a* the soft palate is raised, or if the latter renders the inspection difficult, one adopts the method suggested above (Fig. 163).

Dorn has recommended posterior rhinoscopy with the head of the patient hanging over backward for operations in the naso-pharyngeal cavity.

An accurate comprehension of the rhinoscopic picture (see Fig. 164) usually requires no small amount of practice, and often affords great difficulties to beginners. The posterior margin of the nasal septum running from above downward is the best guide, or farther back in the field of vision the arch of the pharynx which is attached to the base of the skull and the upper vertebræ, and which becomes continuous with the posterior wall of the pharynx. On both sides of the septum one sees more or less of the superior, middle and inferior turbinated bones and of the middle and inferior meatus. Below this is seen the nasal surface of the soft palate, and to the side the Eustachian prominence with the opening of the tube. The posterior upper wall of the pharynx has a peculiar cleft appearance, as it is permeated with adenoid tissue, the so-called pharyngeal tonsil (see Fig. 165). In this cleft tissue there usually appears distinctly the orifice of the pharyngeal bursa which lies behind the mucous membrane of the pharynx (Fig. 165, 7). Laterally the posterior pharyngeal wall passes over into Rosenmüller's fossæ (pharyngeal recesses) which lie behind the Eustachian prominence (Fig. 165, 6).

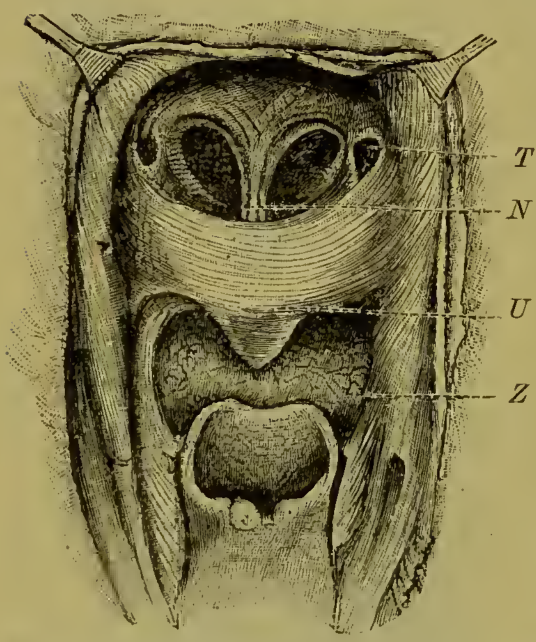


FIG. 166.—Naso-pharynx, pharynx, and entrance to the larynx seen from behind: *T*, orifice of the Eustachian tube; *N*, nasal septum; *U*, uvula and soft palate; *Z*, tongue.

Aside from inspection, palpation of the nasal cavity, and especially the naso-pharyngeal space, with the finger is of great importance, and in certain cases never to be omitted. To perform this, one stands on one side of the patient, who is seated, passes the bent forefinger behind the soft palate and feels the posterior surface of the soft palate, the nasal septum, the posterior nares, the Eustachian prominence, Rosenmüller's fossa, and the superior and posterior wall of the pharynx. By this palpation one can determine the presence of tumours, adenoid growths, foreign bodies, sequestra, or exposed carious bone, etc. If there is fear lest the patient bite the finger of the surgeon, the mouth must be held open with a gag, or one may protect the finger with a metallic shield. The combined internal and external palpation is especially suited for the lateral portions of the pharynx.

Examination with the probe should also be mentioned, which we frequently make use of in the nasal cavity.

§ 40. **Diseases of the Nasal Cavity.**—Diseases of the nasal cavity are of great general importance, and it is very necessary to be skilled in their examination and diagnosis. I need only mention that epilepsy, asthma, persistent cephalalgia, and incomplete development and atrophy in children, may be caused by diseases of the nose. Hæmorrhage from the nasal cavity should be mentioned first. Nosebleed, or epistaxis, is the result either of traumatisms or various pathological conditions such as inflammation or tumours inside the nose, chronic ulceration, perforating ulcer, varicosities, congestion of the branches of the superior vena cava, erysipelas of the nose, infectious diseases such as typhoid; moreover, constitutional disturbances, dysmenorrhœa, etc. Francaviglia found as the cause of a violent persistent epistaxis a leech which had probably got into the nose while the patient was drinking out of a country brook. Hæmophilia gives rise to very serious recurrent attacks of epistaxis. The hæmorrhage originates most frequently in the anterior part of the nose, from the erectile tissue of the inferior turbinated bone, and from the cartilaginous nasal septum. The blood comes in drops and the hæmorrhage usually ceases of itself, but so much blood can be lost that energetic measures must be adopted, especially in the case of patients who are already anæmic and suffering from fever. One must also, in dealing with feverish and delirious patients, pay especial attention to epistaxis, lest a large amount of blood run through the posterior nares into the lungs, the œsophagus, and the stomach. Septic inflammation of the lungs or suffocation may ensue from accumulation of blood in the lungs.

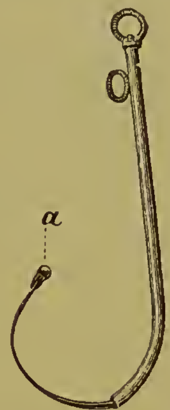


Fig. 167.—Bellocq's canula.

The treatment of epistaxis consists, in mild cases, in the aspiration of cold water or ice water to which a little vinegar, tannin, or alum may be added. It usually suffices to press the alæ nasi together firmly from the side. If the hæmorrhage is more severe, it is a good plan to pack the nose by pushing iodoform gauze or absorbent cotton toward the posterior nares with a curved dressing forceps, and also pressing it into the upper part of the nose. In the more serious cases the tampons lie for a day or two. Cocaine (a twenty- to thirty-per-cent solution with the addition of a little glycerin) has proved of late a most excellent hæmostatic (A. Ruault). Small cotton plugs are saturated with the solution. The desired result ensues immediately, and after an hour or two the pledgets may be removed. In cases of fresh wounds in the nose the tampons must be removed promptly in order that no symp-

toms of poisoning may develop. In more serious cases of hæmorrhage from the nose turpentine has been used with success.

Bellocq's canula is a useful instrument for packing the nose (Fig. 167). Within the tube there is a pliable metallic rod which can be pushed forward and backward. The tube is introduced, with the steel spring drawn back, through the nostril nearly to the posterior pharyngeal wall. The rod is then pushed forward into the oral cavity. A tampon of cotton or gauze is fastened to the hole at its end (see Fig. 167 *a*) by means of a silk thread, and the tube is then drawn out again through the nostril. In this way the posterior nares can be firmly packed. The tampon must not be too small, as it should fit snugly into the posterior part of the nasal cavity. One of the ends of the thread attached to the tampon should be brought out through the nostril, and the other out through the mouth, and they should be fastened upon the cheek with adhesive plaster. After a day or two the tampon can be removed by pulling on the thread that lies in the mouth. As a substitute for Bellocq's canula a rubber catheter may be used, or a strong piece of twine stiffened with wax.

Epistaxis has also been arrested by tamponing the nasal cavity by means of an India-rubber tube, the so-called rhineurynter (see Fig. 168). The tube is introduced when empty into the nasal cavity along the

FIG. 168.—Englisch's rhineurynter: *a*, bulb for the posterior nares; *c*, bulb for the external nares; *b*, connecting piece between both bulbs; *d*, rubber tubing that protrudes from the nostril.

floor of the nose, and then filled full of water or air. The part of the tube protruding from the nose (Fig. 168 *d*) is closed by tying it off with a thread.

Inflammation of the Mucous Membrane of the Nose (Rhinitis) is very common. It consists either of acute and chronic catarrh, or of diphtheritic, croupous, phlegmonous, or ulcerative inflammation.

Acute catarrh (coryza) is most frequent. This is familiarly known to every one as cold in the head, and constitutes an infectious disease *sui generis*. The "cold" is merely the predisposing cause. Coryza is characterized anatomically by hyperæmia and swelling of the mucous membrane of the nose. At first a thin serous mucus is secreted, and the later secretion has a more purulent character. Nasal respiration is more or less interfered with or altogether suspended. The inflammation often passes over to the accessory cavities of the nose, especially the frontal sinuses, and it is then combined with a characteristic dull frontal headache. Coryza that has be-

come chronic is very frequently accompanied by polypous growths of the mucous membrane of the nose.

The more marked degrees of coryza sometimes occasion serious symptoms among infants, because they are exposed to the danger of suffocation while asleep, and are unable to take the breast or bottle properly on account of the suspension of nasal respiration. Coryza among newborn infants may be the result of infection with gonorrhœal vaginal secretion, though this is much less common than gonorrhœal conjunctivitis resulting from the same cause.

The treatment of coryza is, generally speaking, of little effect. Its duration can sometimes be very much shortened by the internal administration of quinine, by the insufflation of a powder containing carbolic acid, chloride of ammonium, and salicylic acid, and by steam baths. Cotton tampons soaked in boric acid, bismuth, or salicylic acid, nasal douches containing a solution of bismuth, and insufflations of boric acid, bismuth, and oxide of zinc, from in front or from the posterior nares, are also to be recommended.

Chronic nasal catarrh, or ozæna (chronic rhinitis), appears frequently as an accompanying symptom of various diseases, particularly scrofula, tuberculosis, and syphilis, less frequently among individuals who are otherwise perfectly sound. Two forms of chronic rhinitis may be distinguished anatomically, the hypertrophic and the atrophic. In the hypertrophic form the mucous membrane is thickened, whereas in the atrophic form it becomes thinner and thinner, and finally Bowman's glands also atrophy; the erectile tissue of the turbinated bones, in case of long continuance of the disease, becomes atrophic, as well as the bones themselves, so that the nasal cavity is correspondingly enlarged. The atrophic form is usually secondary to the hypertrophic form. In both forms of chronic rhinitis—particularly, however, in the atrophic form—there is a yellowish or greenish purulent secretion which is filled with the microbes of decomposition, and consequently emits a fœtid, offensive odour (simple ozæna, rhinitis chronica atrophica fœtida). B. Fränkel and Michel have recently described this simple ozæna in detail. The accessory cavities of the nose, and especially the pharynx, are very frequently affected in this simple ozæna. Ulcers are comparatively rare, but sometimes form beneath the hard, offensive crusts. Simple ozæna is, in the main, a form of atrophy of the mucous membrane, or, according to Schuchardt, a peculiar process of inflammation which leads to a cicatricial shrinkage, and is characterized by metamorphosis of the epithelium of the mucous membrane into horny epithelium.

Ulcerative ozæna is chiefly a result of tubercular and syphilitic processes (see page 275).

It is a fact of special interest that through pathological changes in the erectile tissne of the turbinated bones, particularly swelling and hypertrophy of the inferior and middle turbinated bones, nervous

reflex disturbances sometimes arise (sneezing, asthma, neuralgia, of the fifth nerve, for example, particularly migraine, gastralgia, etc.), so that their partial or total excision becomes necessary (Hack).

Simple ozæna is very obstinate as soon as it passes into the atrophic form.

The treatment of simple ozæna is partly local and partly directed against the existing constitutional disease (scrofula, tuberculosis, syphilis, etc.). The nasal cavity must, above all, be freed from the offensive crusts by means of injections with the nasal douche, or by the use of the sharp spoon or suitable brushes. One may use as a nasal douche an ordinary irrigator, or any vessel provided with an India-rubber tube which has an olive-shaped attachment. Solutions of chlorate of potash, boric acid, thymol, and permanganate of potash are especially adapted for douching the nose. Nasal douches must be used with care, lest by the entrance of the liquid through the Eustachian tube into the tympanic cavity inflammation of the latter result. Many, therefore, prefer to syringe out the nasal cavity from in front or from the posterior nares. At night, and also during the day, tampons of cotton, from three to five centimetres long and as thick as the thumb, or India-rubber tubes enveloped in cotton and besmeared with the ointment of yellow precipitate, are introduced into the nose, or this salve is applied to the nose and pharynx with a brush. Applications of nitrate of silver (1 to 10), of ten- to fifty-per-cent trichloracetic acid or of trichloracetic acid with glycerin and iodine (0·15 : 30·0 glycerin, 0·15 pure iodine, 0·2 iodide of potassium), after previous and subsequent use of cocaine (Stein, Bronner, Jurasz, Ehrmann), are serviceable. In case of simple ozæna in a very narrow nasal cavity, Volkmann recommends removal of the inferior and the greater part of the middle turbinated bone with a large gouge, for the purpose of securing better ventilation of the nose. This operation is also indicated for the above-mentioned nervous reflex disturbances (Hack). One introduces as large a gouge as possible into the nostril and pushes it back two or three times in the direction of the middle meatus, parallel to the hard palate. In hypertrophic rhinitis, galvano-caustic cauterization of the mucous membrane, and removal of portions of mucous membrane from the inferior and middle turbinated bones with the galvano-cautery snare, for example, after applying a from ten- to twenty-per-cent solution of cocaine with the brush, are very effective.

As a general rule, it is well to bear in mind that the hypertrophic form is to be treated with astringents, and the atrophic form, on the contrary, with Lugol's solution of iodine, glycerin, chlorate of potash, or sodium carbonate. For clearing the accessory cavities of the nose,

the use of Politzer's method is especially to be recommended (see Diseases of the Ear).

Perforating Ulcer of the Nasal Septum.—The perforating ulcer of the nasal septum is, according to Weichselbaum and Hajek, a progressive necrosis of the mucous membrane and cartilage within the cartilaginous nasal septum, which has a very chronic course, is caused by the *Staphylococcus pyogenes aureus* and *Streptococcus pyogenes*, leads to perforation of the septum, and then—seldom sooner—heals spontaneously. The disease often begins with hæmorrhages. The defect which finally ensues is usually circular, and has a smooth margin. It is not due to syphilis or tuberculosis.

Blennorrhœa of the Nose from gonorrhœal infection is rare, and is characterized by a continued suppurative discharge. In such cases one has first to determine whether the suppuration is confined to the nasal cavity, or whether the accessory cavities, especially the antrum of Highmore and the frontal sinus, are involved in the disease. In the former case an astringent treatment suffices, with use, it may be, of the thermo-cautery. The treatment of empyema of the frontal sinus and the antrum of Highmore is given in §§ 24, 49.

Hay Fever.—By hay fever is understood an acute inflammation of the mucous membrane of the nose, the conjunctiva, the oral cavity, the pharyngeal cavity, the larynx, and the bronchi, which occurs especially, in our section of the country, from May to July, and is occasioned by the pollen of flowering grasses and grains, by the pollen of many roses, as well as by powdered drugs (ipecacuanha, hellebore, lycopodium, etc.). Contact between the mucous membrane of the nose and the hairs of many animals, or the particles of dust that cling to them, also produces an attack of hay fever. The higher classes are especially predisposed to the disease.

The affection begins, as a rule, suddenly, with very severe acute rhinitis, accompanied by sneezing, swelling of the eyelids and neuralgic symptoms in the distribution of the fifth and occipital nerves. Fever is very often absent. Distinct asthmatic attacks sometimes accompany these symptoms. The symptoms generally subside very quickly, after a few hours or days, and then immediately return as soon as the injurious influences operate anew, so that the patient is tormented by such recurring attacks of coryza for weeks, or months even, until the beginning of colder weather. The prognosis is good. The treatment consists, above all, in bringing the patient into an atmosphere that is as free as possible from pollen. Residence in large cities is favourable, and residence by the sea is particularly so. Wearing tampons of cotton in the nasal cavity, a veil, and tightly closing glasses before the eyes is serviceable. As local treatment, irrigating the nose during the attack with a one-per-cent solution of quinine has a good effect, as does the use of opiates. The strengthening of the nervous system by treatment suited to this end is also important. After the attack has run its course, the nasal cavities should be carefully examined, and if predisposing pathological changes are found they should be treated. The destruction of swellings of the inferior turbinated bone with the galvano-cautery has an especially favourable effect, and this has been recommended particularly by Daly, Hack, Moldenhauer, and Beschirner. Attention should be paid to such

swellings of the turbinated bones, or of the pharynx, and to any mucous polypi, especially in the asthmatic form of hay fever.

Croup and Diphtheria of the Nasal Cavity.—Croup and diphtheria are, generally speaking, secondary to diphtheria of the fauces and but seldom primary; they are located particularly in the posterior part of the nose (see § 67, Diphtheria and Croup).

Submucous (Phlegmonous) Inflammation of the nasal cavity—that is, of its muco-periosteal lining—is a less frequent affection. It may result from traumatism, phlegmonous inflammation in the vicinity, catarrh, and especially blennorrhœa. Circumscribed abscesses occur most commonly in the anterior epidermic portion of the nasal cavity and on the septum. They result usually from a furuncle or an injury, and are not uncommon in children.

The symptoms of phlegmonous inflammation of the muco-periosteal lining of the nasal cavity are usually severe swelling of the mucous membrane and hyperæmia and swelling of the skin of the nose and its vicinity. The course is generally very acute. The secretion from the nose is normal or purulent. After spontaneous or artificial opening of circumscribed abscesses, recovery usually follows very quickly. In exceptional cases, however, death from meningitis has been observed. Circumscribed caries or necrosis sometimes occurs secondarily.

The phlegmonous inflammation sometimes localizes itself mainly in the accessory cavities of the nose (antrum of Highmore, frontal sinus, sphenoidal sinus) and in the ethmoidal cells. Weichselbaum has described such cases in detail.

The treatment of phlegmon of the nasal cavity is, above all, antiphlogistic. The cause of the affection should also be taken into consideration. As soon as circumscribed suppuration can be made out at any point, the abscess must be incised. In abscess of the nasal septum a simple incision is often insufficient. The best way is to make a cruciform incision, remove a part of the mucous membrane, and scrape away the necrotic tissue with a small sharp curette.

Tuberculosis of the Nasal Cavity occurs either secondarily after lupus of the outer cutaneous covering, or it may arise primarily in the mucous membrane, the periosteum, or the bone. As regards the frequency of primary tuberculosis of the mucous membrane of the nose, which takes the form both of tubercular ulceration and tumour formation, there is a difference of opinion. It is, generally speaking, rare. In connection with a case of typical tuberculoma of the mucous membrane of the nose in Bruns's clinic, Kikuzi collected twenty-two cases from literature. Michelson, B. Fränkel, Seifert, Hajek, and others have increased the number by still other cases. The size of the

tumour varies from that of a cherry to that of a walnut, and miliary tubercles are usually found in the neighbourhood. After some time, tuberculosis of the mucous membrane leads to caries of the underlying bone. The destruction of the nose from tuberculosis is usually not so great as from syphilis. Ozæna also occurs in connection with tuberculosis of the nasal cavity, as has been already mentioned (ozæna tuberculosa), but this is by no means so frequent as syphilitic ozæna.

The treatment of tuberculosis of the nasal cavity should consist of a suitable strengthening treatment of a general character (see Principles of Surgery, § 83, Tuberculosis) and of a prompt and energetic local treatment, much as in syphilis, consisting mainly in the use of the sharp spoon and the galvano-cautery, the nasal cavity being opened, if necessary, by an incision in the middle line or to one side, after Bruns (see page 281).

Syphilis of the Nasal Cavity is very common. It seldom begins here in the form of a primary sore, but we have almost always to do with a secondary stage of the disease. Syphilis of the nasal cavity in the earlier stages of syphilis takes the form of a syphilitic catarrh (coryza syphilitica), with the formation of erythematous macules and papules with ulceration, which may lead to necrosis of the cartilage and the bone. Syphilitic ulcers of the nasal cavity arise most frequently in the later course of syphilis, from gummatous inflammation of the mucous membrane, and especially of the periosteum and the perichondrium. These gummata, which appear in part as circumscribed nodules and in part as more diffuse inflammatory processes, lead finally to ulceration and breaking down of the soft parts, as well as of the bone and cartilage, so that, under certain circumstances, extensive destruction of the nose ensues, especially of the bony framework. The bone may finally be completely destroyed by caries and necrosis, so that the so-called saddle-nose results, which is so characteristic of syphilis (Fig. 169). In these syphilitic affections of the nasal cavity an ozæna is developed (ozæna syphilitica) caused by the ulcerations, the sequestra, and the purulent secretions dried to foul, offensive crusts. The course of syphilis of the nose is generally extremely prolonged. The disfigurements arising from it may be very marked, and affect both the outer and the inner nose. Death from meningitis or sinus thrombosis

Fig. 169.—Destruction of the bony framework of the nose due to syphilis in a man thirty-eight years old.

may result from spreading of the syphilitic inflammation to the ethmoidal cells and the cranial cavity.

The treatment is local and constitutional and should be as energetic as possible. For the constitutional antisyphilitic treatment, which is of the greatest importance, the reader is referred to Principles of Surgery, § 84. Darzens recommends giving iodide of potassium with iodide of sodium and iodide of ammonium internally, whereby an energetic action is secured. The local treatment, in case of ulceration with destruction of the soft parts and the bone, is chiefly operative—that is, the necrotic soft parts, cartilage, and bone are scraped out of the nasal cavity with the sharp spoon after the nose has been completely divided, if necessary, in the middle line (see pages 280–282). The hæmorrhage is usually profuse. In order that the blood may not be aspirated into the lungs, and here, by its decomposition, occasion septic inflammation or suffocation, the operation is performed with the head hanging over backward or with the patient sitting and inclining his head forward. Use is made of the mixed morphine-chloroform narcosis, so that, while the patient has no sense of pain, he retains control over his swallowing movements (see Principles of Surgery, § 16, page 41). The hæmorrhage is arrested after the operation by packing with iodoform gauze. The gauze is removed in a few days, after it has become loosened. The after-treatment consists in douching or syringing out the nose with antiseptics; also in the insufflation of boric acid, the application of yellow precipitate ointment with the brush, etc., as described above (page 272) for chronic rhinitis.

Syphilitic catarrh and ulcers of the nasal cavity without necrosis and without caries are treated in essentially the same way as chronic rhinitis, according to the rules given on page 272.

Syphilitic defects are remedied by plastic operations (see § 42, Rhinoplasty).

For a description of glanders and leprosy of the nose, see Principles of Surgery, §§ 78, 85.

Foreign Bodies.—Foreign bodies most frequently reach the nasal cavity through the nostrils. They are found especially among children and the insane. The bodies most commonly pushed into the nose by children are beans, peas, glass beads, pebbles, etc. The foreign bodies which enter the nasal cavity from the posterior nares are usually particles of food from the mouth, or portions of the stomach contents which are vomited. Round worms have now and then gained entrance to the nasal cavity and its accessory cavities from the stomach, and have remained there a long time, causing very severe pain (Thiedemann).

The symptoms which are caused by the presence of a foreign body in the nasal cavity are very variable. It is usually soon discovered and removed.

If this is not the case, long-continued trouble, such as pain, suppuration, ozæna, caries, and necrosis, may ensue until it is removed. In cases of chronic unilateral affections of the nose, especially among children, one should always consider the possibility of the presence of a foreign body. Such bodies have repeatedly been finally found as the cause of nasal trouble of many years' duration. Hessler removed from a patient with offensive suppuration of the nose a piece of black, badly smelling laminaria, a centimetre thick and one and a half centimetres long, which had lain fourteen years in the left side of the nose. and had led to perforation of the nasal septum.

Foreign bodies which remain long in the nose sometimes give rise to the formation of concretions, the so-called rhinoliths. Phosphate and carbonate of lime, as well as thickened secretion from the nose, are deposited about the foreign body as a nucleus. The consistence and the size of these rhinoliths are very variable. They lie mostly in the inferior meatus. Rhinoliths have been observed in the nasal cavity of such hardness and size that it was necessary to break them up with a lithotrite before they could be extracted. In one case I found in the nasal cavity a very large broken-off osteoma of the ethmoid bone. The partial calcification of the mucous membrane of the nose and its accessory cavities, which occurs especially among older people, and also now and then among younger persons, must not be confounded with rhinoliths (B. Fränkel).

The diagnosis is usually easy, as the patient is generally brought immediately to a physician with the definite statement that there is a foreign body in the nose. One can frequently see the body without the necessity of an examination with the reflector or the probe. In cases of longer standing it is often covered with secretion, so that the diagnosis is more difficult. In every case of chronic rhinitis one should, as has been said, consider the possibility of the presence of a foreign body.

The treatment for foreign bodies consists in their extraction with a small forceps, a bent dressing forceps, a small sharp spoon, or a probe bent like a hook. The latter is pushed behind the foreign body, and then drawn forward with it. In case it is very large, temporary detachment of the ala nasi may be necessary. If it is situated far back, and can not be extracted from in front through the nostril, one may push it back into the pharynx and remove it through the mouth. It is then swallowed sometimes and discharged *per rectum*. If the body enters the larynx and the lung, it may here occasion severe symptoms. To prevent this, the head should be inclined forward, or, if necessary, two fingers may be passed behind the soft palate to seize it.

Vegetable and animal parasites and insects are sometimes found in the nasal cavity. Of vegetable parasites the various pathogenic microbes are to be mentioned—e. g., in tuberculosis, glanders, leprosy, etc., also mould fungi and yeast fungi. To the latter belongs also the oidium albicans (see The Oral Cavity).

Of the infusoria, different varieties of cercomonas have been met with in the nasal cavity (B. Fränkel).

Insects creep into the nose, especially during sleep. Millepeds (*Scopolendræ*), earwigs (*Forficula*), and Dermestes have occasionally been found in the nasal cavity. Millepeds have, in certain cases, remained for years in the

frontal sinuses also, occasioning the severest pain. In exceptional cases, finally, leeches, worms, nematoids, for example, and fly-maggots have been observed in the nasal cavity. Flies sometimes, in the tropics more frequently than with us, lay their eggs in the nostrils of persons who are afflicted with ozæna and sleep in the open air by day. Cases of death have been known in consequence of the nesting of fly-maggots in the nasal cavity.

The symptoms occasioned by insects in the nasal cavity vary according to the number, the kind, and the size of the creatures and the length of time which they remain. Severe pain and inflammatory symptoms are usually present as well as the feeling of a foreign body moving about. That the pain may be very severe is illustrated by the statement of Weber and B. Fränkel, that the soldiers of the French army in Mexico who had fly-maggots in the nose killed themselves. Dizziness, delirium, unconsciousness, and mental disturbances have been observed in consequence of insects in the nasal cavity and its accessory cavities, so that the trouble has sometimes been mistaken for meningitis.

The diagnosis of parasites and insects has often only been made when they left the nose, or at the autopsy of the patient. Fly-maggots in the nasal cavity are always to be recognised in consequence of their constant motion.

The treatment consists in the removal of the creatures after the nasal cavity and its accessory cavities have been, if necessary, sufficiently opened. One may also kill them by the inhalation of chloroform or ether, by injection of bichloride of mercury or turpentine, by the insufflation of calomel, etc.

§ 41. **Tumours of the Nasal Cavity.**—Of tumours of the nasal cavity, the more or less pedunculated or sessile excrescences of the mucous membrane of the nose, the so-called nasal polypi, occur most frequently. We have mostly to do with soft polypi—that is, with so-called mucous polypi, which, according to the investigations of Billroth and others, are to be regarded as a genuine hypertrophy of the mucous membrane, since they retain its structure. The mucous glands often undergo a cystic dilatation in these polypi, and the cysts are sometimes so large that the polypi seem to be made up of one or several of them. The so-called dropsy of the antrum of Highmore and that of the frontal sinuses arise sometimes from mucous polypi that have undergone this cystic degeneration (Virchow). The polypi frequently contain many newly formed and enlarged glands (adenomatous polypi), or they are markedly vascular (teleangiectatic polypi). Other mucous polypi show the structure of myxomata. The hard polypi are essentially fibromata. They are less frequent.

Polypi appear especially in the course of chronic catarrh. They are single or multiple, and may be found in one or both nasal cavities and in their accessory cavities (see especially frontal sinus and antrum of Highmore). The favourite location of polypi is the anterior and upper part of the nasal cavity, especially the middle turbinated bone.

The symptoms of nasal polypi consist chiefly in manifestations of chronic catarrh and obstruction of the nasal cavity. If one nostril is closed and the patient blows through his nose with his mouth shut, one easily sees that the nasal cavity is more or less stopped up or entirely impervious. Patients with nasal polypi or with nasal tumours of any kind breathe chiefly through the mouth and have a very characteristic speech. Asthmatic trouble sometimes exists. The polypi may be of such size and in such numbers as to protrude through the nostrils and the posterior nares. In such cases I have frequently seen that the bones of the nose were defective in some places, in consequence of atrophy from pressure.

The diagnosis of polypi is made by inspection and palpation of the nose. The inspection is made with the naked eye or with the rhinoscopic mirror; posterior rhinoscopy is particularly valuable in determining whether the polypus has grown through the posterior nares backward into the naso-pharyngeal space or whether it originated here. The examination of the naso-pharyngeal space with the finger should never be omitted.

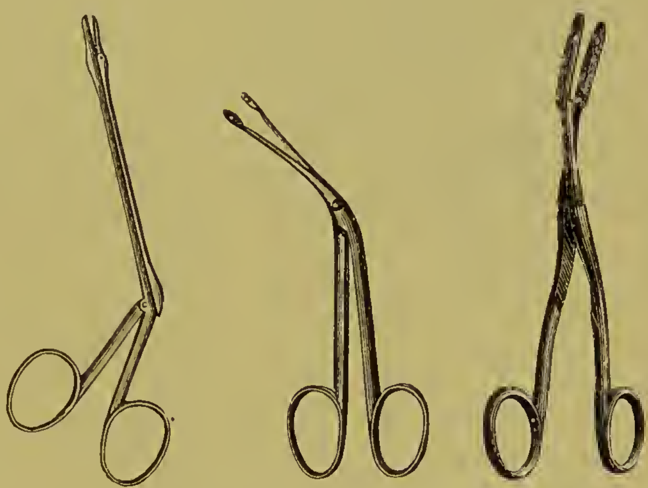


Fig. 170.—Forceps for the extraction of nasal polypi.

The prognosis is good, though recurrences often take place.

The treatment of nasal polypi consists in their removal with a slightly curved dressing forceps or the so-called polypus forceps (see Fig. 170). The nasal cavity is first painted with a from ten- to twenty-per-cent solution of cocaine, or one may make use of the mixed morphine-chloroform narcosis (see Principles of Surgery, § 16, page 41). The patient's head is bent slightly backward, and one then, with or without the use of a nasal speculum, pushes the forceps into the nose as far as the pedicle of the polypus and removes the latter by rotating the forceps and pulling vigorously. The rhinoscopic mirror can not be used, as a rule, on account of the hæmorrhage. In case there are several polyps the same process is repeated. One must always try to feel the polypus with the forceps and to seize it properly. The best plan is to push the forceps at first along the nasal septum upon the floor of the nasal cavity, in order to remove any

polyps that there may be between the lower turbinated bone and the septum, then to carry the forceps between the inferior and middle turbinated bones, then between the middle and superior turbinated bones, and finally into the superior meatus and along the roof of the nasal cavity. Sound portions of the mucous membrane, or of the turbinated bones, are usually torn out at the same time. The extraction of polyps that are situated farther back may often be much facilitated by passing the finger from within the mouth into the naso-pharyngeal space and pressing the polypus from behind forward between the blades of the forceps. In removing polyps in the neighbourhood of the posterior nares, one should make use of posterior rhinoscopy. After using the forceps, it is often necessary to scrape out the nasal cavity with the sharp spoon, in order to remove the small polyps which can not be seized with the forceps. The hæmorrhage, which is sometimes severe, is arrested by a cold or hot douche, or by packing with iodoform gauze. In order to prevent recurrences it is a very good plan to paint the cavity with a from fifteen- to twenty-per-cent solution of cocaine after a few days, and then, in one or several sittings, to cauterize lightly the places where the pedicles of the polypi were, or the entire nasal cavity with the galvano-cautery.

Of other methods of removing nasal polypi I mention especially the use of the galvano-cautery snare (see Principles of Surgery, pages 75–78 ff) and of the cold-wire snare, similar, for example, to Wilde's snare for polyps of the ear. The use of these snares is, in my opinion, more difficult. The use of the forceps seems rougher, to be sure, but it is simpler at all events, and accomplishes the object more quickly. Cauterization, judging from my own experience, is especially adapted, as has been said, for the small polypi which can not be grasped and for those in the upper part of the nasal cavity.

If one wishes to be sure of avoiding recurrences and to remove especially all the small polypi in the upper part of the nose, it is often necessary to make the nasal cavity accessible by dividing the external nose. Division of the nose in the middle line usually suffices, and if such a wound is carefully sutured it heals perfectly in a few days, so that the cicatrix is scarcely noticeable later. By dividing the nose in the middle line one or both nasal cavities may be opened. If it is desired to open both, this may be done from a single external incision through the skin in the middle of the dorsum of the nose. This incision is then made bifurcated at the tip of the nose near the nostrils. The nasal cavity is opened by piercing the cartilaginous portion of the nose with a curved bistoury from each nostril, corresponding with the external cutaneous incision, and then opening each nasal fossa along

the course of the external incision. If it is desired to open also the bony framework of the nose, one divides the bone through the same cutaneous incision with the chisel or with a bone-cutting forceps. Division of the cartilaginous portion of the nose in the middle line usually renders the nasal cavity only slightly accessible.

Rouge recommended in suitable cases the temporary detachment of the soft parts of the nose (Fig. 171). This involves detachment of the upper lip from the upper jaw by an incision from the first bicuspid on one side to that on the other side, detaching the cartilaginous septum from the anterior nasal spine, and the cartilages of the alæ nasi from the superior maxillary bone. If necessary, the bony nasal septum is also divided with straight bone forceps. The detached nose is turned upward against the forehead (Fig. 171). After the completion of the operation the nose is replaced in its normal position.

Fig. 171.—Temporary detachment of the nose (Rouge).

Finally, temporary or osteoplastic resection of the nose can be undertaken in various ways and the nose reflected *in toto*. Immediately after the operation or after a certain time has elapsed, the nose is replaced and allowed to heal on again after careful suture. This temporary resection of the nose is a very thorough method, and is particularly adapted to the treatment of naso-pharyngeal polyps (see also § 69) and for other new growths in the upper and posterior parts of the nasal cavity. Chassaignac, Bruns, Langenbeck, Linhart, and Ollier have suggested various methods of performing this operation.

The best method of osteoplastic resection of the entire nose is that of Ollier or that of Chassaignac and Bruns. Ollier displaces the nose downward over the mouth by dividing the skin and the bone or cartilage on each side in the naso-buccal furrow and at the root of the nose (see Fig. 172). The nasal septum is, of course, divided in the same plane. Chassaignac and Bruns displace the nose to one side by dividing the skin and bone or cartilage at the root of the nose and in the naso-buccal furrow, and dissecting the alæ nasi from the upper lip (see Fig. 173). Here also the bony and cartilaginous nasal septum is divided in the same plane.

Unilateral osteoplastic resection of the nose, after Langenbeck, is performed by transfixing the cartilaginous portion of the nose from within the nasal cavity and dividing it from the edge of the bony portion as far as the nostril along the nasal septum. The skin and periosteum of the bony dorsum of the nose are then incised in the middle line, and the dorsum divided with a chisel or a bone-cutting forceps. A second incision is then made in the naso-buccal furrow from the insertion of the ala nasi to a point below the inner canthus of the eye, and the cartilaginous and bony portions of the nose are here also divided, the lachrymal sac being avoided. The cartilaginous and bony portions of the nose are then finally reflected upward, the connection between the nose and the frontal bone being broken in with a periosteal elevator.

Fig. 172.—Osteoplastic resection of the nose (Ollier).

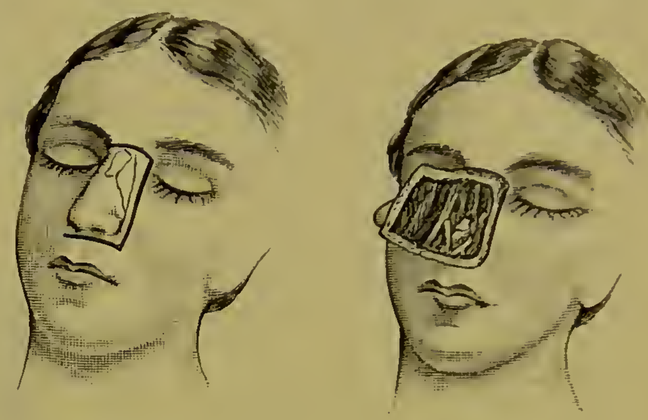


Fig. 173 *a*. Fig. 173 *b*.

Osteoplastic resection of the nose (Chassaignac and Bruns): *a*, cutaneous incision; *b*, nose reflected to the side.

One may also leave the cartilaginous portion of the nose intact and perform a temporary resection of one side of the bony portion of the nose by making an angular incision, after Linhart, for example, in the middle line of the dorsum of the nose and along the apertura pyriformis. The cartilaginous part of the nose is thus separated from the bony portion. The bony portion of the nose is then divided in the middle line, and the nasal bone and the nasal process of the superior maxillary bone are divided transversely and subcutaneously at the root of the nose with the chisel or the bone-cutting forceps, and the cover of skin and bone is then finally reflected outward. The temporary resection of the nasal process of the superior maxillary bone in a similar manner has been recommended by Langenbeck, who then displaces the flap of skin and bone in an upward direction.

The other tumours of the nasal cavity and its accessory cavities originate chiefly in the periosteum and the perichondrium, or in the bone or cartilage. Hard fibromata, chondromata, osteomata, and sarcomata, in addition to various mixed tumours, and finally carcinomata, occur most frequently. Os-

teomata originate by preference in the ethmoid bone, and grow from here into the neighbouring cavities, including the nasal cavity. I saw a very large osteoma which filled the entire right side of the nose as far as the naso-pharyngeal space. It protruded from the nostril and had become detached spontaneously from the ethmoid bone. Osteomata of the nose are much rarer than those of the frontal sinuses (see § 24, page 179). Carcinomata occur more frequently on the outer skin of the nose. The carcinomata which originate in the mucous membrane are, as a rule, villous or nodular growths, which finally ulcerate. Echinococcus cysts have been observed in the nose in rare cases.

Fibromata of the naso-pharyngeal space, the so-called naso-pharyngeal polypi, which originate mainly in the periosteum of the base of the skull, are of especial importance. We shall describe these more in detail in connection with diseases of the pharyngeal cavity (§ 69).

§ 42. **Plastic Operations on the Nose (Rhinoplasty).**—Plastic operations on the nose are performed for congenital defects; much more frequently, however, for acquired defects and disfigurements following injuries or ulcerative processes in the course of syphilis, lupus, and noma, and, finally, following the extirpation of tumours. We distinguish between complete and partial rhinoplasty according as the whole nose or only certain parts of it are to be newly formed. Partial rhinoplasty is made use of particularly for loss of substance at the tip of the nose, on the alæ nasi, on the septum, or after loss of the entire movable portion of the nose or the bony framework of the same.

Plastic operations with the formation of pedunculated flaps from the immediate neighbourhood of the defect, most commonly from the forehead, seem to have been first invented and developed by Indian physicians. They found abundant occasion for plastic operations on account of the common practice of cutting off the nose and the ears as a form of punishment. This is, therefore, also called the Indian method, in distinction from the Italian method, in which the flap of skin for the formation of the nose is taken from the arm. The Italian method, invented by Kaspar Tagliacozza in Bologna (1547), was later, at the beginning of this century, taken up again and modified by Graefe, for which reason it is also called the German method. The Italian method has never been widely adopted, but it remains of value for those cases in which there is no available skin in the neighbourhood of the defect.

I. **Complete Rhinoplasty (Indian Method).**—In the formation of an entire nose the skin of the forehead should, if possible, always be made use of. Only in case of necessity, when the skin of the forehead is likewise destroyed or has undergone cicatricial change, does one use the skin of the cheek or the upper arm, which is thinner and contracts more.

In case of complete rhinoplasty—when, for example, in place of the nose there is a flat, more or less protuberant skin surface with an irregular opening—the operation consists of the following four parts: 1. Freshening the defect. 2. Marking out the flap on the forehead and dissecting it up. 3. Turning the flap which has been modelled in a definite way, and carefully suturing it into the freshened defect. 4. Reducing the size of the defect in the forehead by suture, or, better, by skin-grafting.

The sides of the defect should be freshened so as to form a triangle with equal sides, whose base lies on the upper lip and whose apex is about at the root of the nose or higher (Fig. 174 *a*). The freshened borders of skin are freed for about half a centimetre from the underlying parts, in order that the flap from the forehead may be better united with the borders of skin surrounding the defect.

Then follows the second part—viz., marking out the flap on the forehead and its detachment. The incision may be made free-hand, or a pattern made from adhesive plaster may first be applied to the forehead and its contour followed with the knife. The flap must, in all its dimensions, be one third larger than the defect, and careful measurements should therefore be taken before marking it out. What form shall the flap have? As is seen by Fig. 175, various shapes have been recommended. The Indian surgeons cut out a simple triangle whose base lay at the hair border and whose apex was at the root of the nose (Fig. 175 *a*). One can then, after dissecting up the triangular flap, divide the base into three parts by two incisions, the middle part being used for the septum and the two lateral parts for the alæ nasi (Fig. 175 *a*). Dieffenbach's flap is shown in Fig. 175 *b* or *c*, and Langenbeck's in Fig. 175 *d* and *e*. Langenbeck's method is the more elegant, and it has the advantage that one can bring the defect in the forehead together better with sutures. The technique of skin-grafting is now so well developed

Fig. 174 *a*.

Fig. 174 *b*.

Complete rhinoplasty: *a*, method of freshening the defect and marking out a pear-shaped flap; *b*, condition after bringing the flap into the defect.

that one will usually cover over the defect on the forehead by grafts taken from the upper arm. Generally speaking, the pear-shaped flap, after Dieffenbach (Fig. 175 *b*), and the flap *d* in Fig. 175, after Langenbeck, are the most practical. The forms *d* and *e* in Fig. 175, after

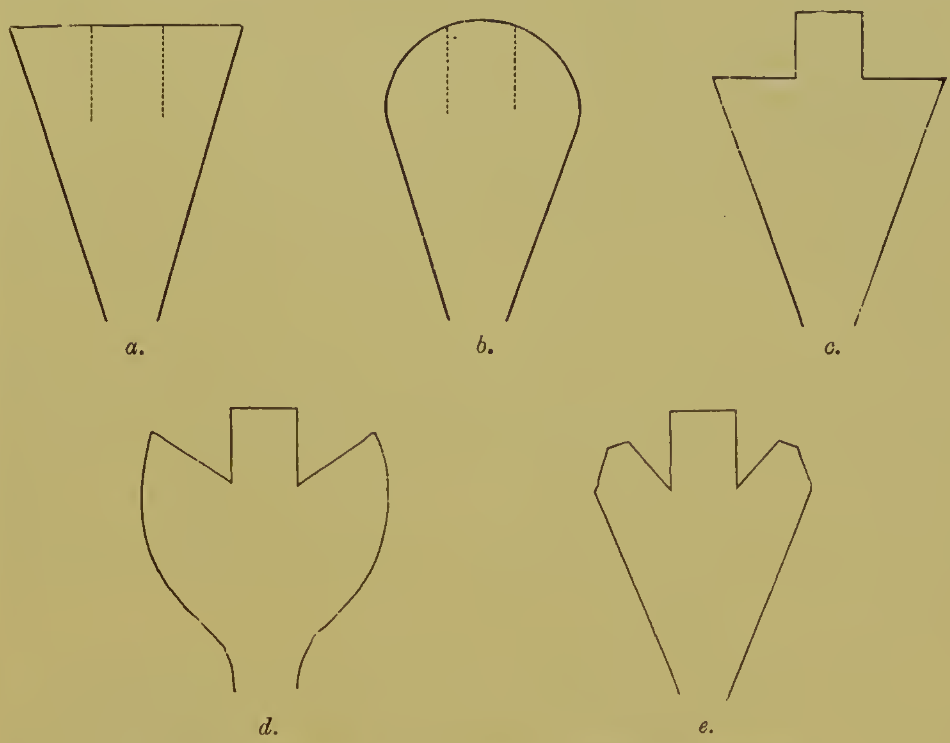


FIG. 175.—Models for frontal flaps in complete rhinoplasty.

Langenbeck, may be formed supplementarily from any pear-shaped flap such as is represented in Fig. 175 *b*.

Many surgeons take the flap laterally from the forehead—that is, more obliquely, as represented in Fig. 174—and this is especially desirable when the forehead is not high, as otherwise hair will be transplanted at the same time. When it is possible I always take the pear-shaped flap (Fig. 175 *d*) from the middle of the forehead (Figs. 177, 179). Whether one cuts out a pear-shaped flap or one of the former represented in Fig. 175 *d*, one must always give special care to the formation of the pedicle. One contour incision runs into the upper angle of the defect, the other to the region of the eyebrow (Fig. 174 *a*, and Fig. 179). To make the turning of the flap easier, after it has been detached, one may lengthen one contour incision somewhat in a lateral direction, as shown in Fig. 174 *a*, or one may let it run off laterally close below the eyebrow in the shape of a hook, as already mentioned in connection with blepharoplasty (see Fig. 129, page 228). In case of complete rhinoplasty it is better to include the periosteum in the

flap—that is, one cuts the flap of skin and periosteum directly from the bone, except at the base of the flap, which is to form the septum and the alæ nasi. In order to retain a sufficiently high nose, and one that does not shrink too rapidly, it is still better, in case the bony framework of the nose is wanting, to chisel away at the same time a ridge of bone from the frontal bone for the dorsum of the nose and the septum, and to transplant it together with the flap from the forehead. Rotter divided the flap of bone with a metacarpal saw into three parts, for the dorsum and the lateral walls of the nose. König's operation is also of value in complete rhinoplasty—that is, one forms a flap of soft parts and bone from the root of the nose and the lower frontal region, and lays the flap of skin from the forehead over it (see page 293, Fig. 188).

After temporarily covering the defect in the forehead with aseptic gauze, the detached flap is turned around into the defect, and in such a way that the pedicle is not twisted, which might interfere with the nutrition of the flap (see Figs. 174, 177). If the pedicle is in danger of being too much twisted, one makes the flap, or rather the pedicle, still more movable by a lateral or a curved hook-shaped incision, in the manner above suggested.

If a pear-shaped flap has been detached, one then makes at its base, with scissors, the two longitudinal cuts indicated in Fig. 175 *b*, and forms from the middle part the septum, and from the two lateral parts the alæ nasi. By cutting from the pear-shaped flap a little triangle on each side, one gets the Langenbeck flap (Fig. 175 *d*), which can still further be trimmed so as to make the shape shown in Fig. 175 *e*. If Langenbeck's flap as given in Fig. 175 *d* or *e* has been formed at the outset, further incisions are of course unnecessary.

In both methods the septum is now formed from the middle portion of the base of the flap by folding it together longitudinally, and this longitudinal fold is secured by means of catgut sutures or by mattress suture. The two lateral portions are also doubled on themselves for the formation of the alæ nasi, and secured in the same way by catgut sutures. If the flap of skin is thin, one dispenses with the mattress suture in constructing the septum and the alæ nasi. The shrinking and adherence of the alæ and the septum are prevented, as far as possible, by this duplicature. If by doubling the lateral portions the alæ nasi are made too thick and the nostrils are too contracted in consequence, one may overcome this difficulty by the excision of a small wedge, or by the removal of subcutaneous cellular tissue.

The next step consists in suturing the flap into the defect. As suture material, fine aseptic silk is the best, and the sutures should

be inserted very carefully. The alæ nasi are first sutured into the angles of the triangular defect, and then the septum into a small vertical incision in the middle of the lower part of the defect. The form of the flap from the forehead as seen from below after suture is represented in Fig. 176. Finally, the lateral borders of the flap are sutured in place. The stitches should not lie too close, and the edges of the skin must be brought together accurately in order that no necrosis may ensue. I usually insert tension sutures of fine aseptic silk, and then fine continuous catgut sutures.

Fig. 176.—View of the new nose from below after being sutured into the defect.

The defect in the forehead is then, finally, closed as completely as possible by suture, as shown in Fig. 177, for instance, and the remaining part of the defect is covered by skin-grafts taken from the upper arm. If the operation has been performed according to Langenbeck's method, the appearance at its close is somewhat as represented in Fig. 177. The defect in the forehead is powdered with iodoform, or if skin has been grafted, it is covered with perforated oiled silk, and an antiseptic protective dressing is applied. The nose, and especially the pedicle, remain without a dressing. The sutures are removed in from two to four or five days.

Fig. 177.—Complete rhinoplasty (Langenbeck).

The secondary operations which have to be undertaken later, after the newly formed nose has healed in its place, consist of a wedge-shaped excision from the usually protuberant pedicle and similar corrections on the alæ nasi.

The wedge-shaped excision from the pedicle is made by many surgeons in from four to six weeks after the nose has healed in place, while the other corrections are made later. One must, generally speaking, not be in haste with these secondary operations. They should never be undertaken until after the flap has stopped shrinking—that is, never before the expiration of three months.

The final result of complete rhinoplasty is usually more satisfactory to the operator than to the possessor of the newly formed nose. The nose is at first very good, but it soon shrinks so seriously that it finally presents only a shapeless protuberance of skin, not a nose in any real sense. The art of rhinoplasty consists in making a nose with a good profile, long, high, and pointed; but this, as a permanent result, is seldom attained.

To improve the final result of complete rhinoplasty as far as possible, and especially to prevent shrinkage and depression of the nose, various modifications have been recommended. One may, for instance, use periosteum and bone or soft parts as a foundation for the flap from the forehead. We have already said that the transplantation of periosteum from the forehead with the flap is to be recommended, except at the base of the pear-shaped flap and

Fig. 178 *a*.

Fig. 178 *b*.

Formation of a bony frame-work for the nose (Langenbeck and Ollier).

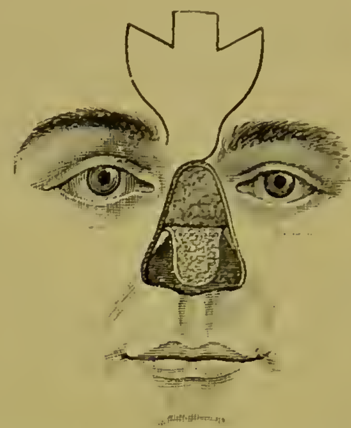


Fig. 179.—Method of making a foundation for the flap from the forehead by a skin-flap from the root of the nose.

at the three upper extremities of the Langenbeck flap, which are to serve for the septum and the alæ nasi. One can cause the periosteum of the nasal process also to heal in beneath this flap of periosteum and skin by detaching the same in the form of a small flap and laying it over the gap in the bone. Langenbeck and Ollier cut one or two strips from the bony margin of the apertura pyriformis, on each side, by means of a small saw (Fig. 178 *a*, 1 and 2) after the skin had been divided by a perpendicular incision and dissected back on each side. The strips, still maintaining their connection with the aperture, are then partially loosened with an elevator, raised like the rafters of a roof over the defect (Fig. 178 *b*), and, with the previously formed skin flaps, are sutured together in the region of the nasal bones. What is left of the nasal bones is then sawn perpendicularly from the nasal processes of the superior maxillary bone and bent upward. Over the framework of bone which is thus formed one lays the flap from the forehead; but this very ingenious method gives no better permanent result than the transplantation of periosteum.

König's method of restoring the bony framework of the nose by taking a flap of soft parts and bone from the root of the nose and the lower region of the forehead, and then laying over this a flap of skin from the forehead, is very strongly to be recommended (see page 293). The simplest way is, no doubt, to transplant a ridge of bone of the proper size for the dorsum of the nose and the septum with and in the usual flap from the forehead.

Hardie replaced the absent bony framework of the nose by causing the freshened tip of the left forefinger to heal into the freshened upper angle of the nasal defect. In the fifteenth week the finger was amputated in the mid-

dle of the second phalanx. A flap of skin has also been detached from the root of the nose and turned downward, with the wound surface on the outside (see Fig. 179), and then over this, as a foundation, the flap from the forehead is laid (Bardeleben, Volkmann, Hueter). As the underlying flap of skin retracts later in an upward direction, the tip of the nose is said to remain permanently elevated.

Wood used as a foundation for the flap from the forehead a longitudinal strip from the upper lip. Ollier and Verneuil placed the flap from the forehead with the wound surface outward, and then laid over it on each side a flap from the nose and cheek. Thiersch reversed this process in the case of a student, the movable part of whose nose had been cut off in fencing (see page 290).

Finally, a supporting framework of gold plate (Dieffenbach), or of metallic wire covered with India rubber (Mikulicz), or of amber (Leisrink), has been introduced into the nasal cavity, in order to prevent in this way the depression of the nose (for particulars, see page 295).

In order to keep the nostrils sufficiently open, Volkmann did not form two separate nostrils, but let the tip of skin upon the flap from the forehead which was intended for the septum hang down free without suturing it to the upper lip. During the process of healing, the free border of the septum rolls more and more inward of its own accord into a spherical nose-tip, which overhangs a little. If desired, one may still form the septum from the upper lip later (see Fig. 187, page 292).

In order to secure a suitable nose-tip, Hueter, after complete healing in place of the new nose, grafted, with satisfactory result, the plantar portion of the little toe, after wedge-shaped excision of the same, into a transverse incision at the tip of the nose.

Madelung performed complete rhinoplasty by dividing the operation into several parts in the following manner: In the first stage of the operation a substitute for the nasal bones was provided by fracturing and raising the nasal process of the left superior maxillary bone, as done by Langenbeck. The mucous membrane of the new nose was formed from flaps of cicatricial tissue and mucous membrane dissected up from all sides, and a large flap of skin from the forehead was transplanted downward to form the defective cheek and to cover over the nasal cavities. Five months later the pedicle of this flap, which lay in the region of the glabella, together with a large part of the remaining skin of the forehead, was likewise transplanted upon the region of the new nose. A year later this conglomerate of skin in the nasal region was transformed into a prominent nose with a tip without detaching the inner adhesions. The principle of this method consists, then, in transplanting as much skin as possible into the region of the nose by operations performed at different times, to let this shrink here, and finally to bring the shrunken mass of skin into a suitable form and position.

II. Rhinoplasty for restoring the entire movable (cartilaginous) portion of the nose, while the bony portion is intact, may also be designated as complete rhinoplasty. One pursues essentially the same course here as has been described above for rhinoplasty when the entire nose has been lost.

The skin of the dorsum of the nose is divided in the median line and dissected back somewhat, laterally, and a flap from the forehead is then grafted in as described above. One may dispense with division of the skin of the dorsum of the nose by laying the pedicle of the flap from the forehead over the preserved skin of the bridge of the nose, and then excising the pedicle later, after the flap has healed in its place. It is better, no doubt, to use the skin of the dorsum of the nose to form a foundation for the flap, as in Fig. 179. Nélaton formed the movable part of the nose from a rhomboid-shaped flap of periosteum and skin from the cheek on each side, whose nutritive pedicle lay near the inner canthus of the eye and the root of the nose (see Fig. 180). This rhinoplasty from the cheek, after Nélaton, is also designated as the French method. The procedure devised by Serre is similar (see Fig. 181).

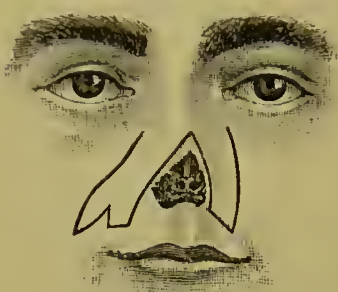


Fig. 180.—Rhinoplasty with tissue from the cheek (Nélaton).

Mason cut a rectangular flap from the cheek on each side, turned it over inward, formed a flap in the same way from the skin at the root of the nose which he turned downward, and laid over these three flaps another from the forehead. Thiersch, in the case of a student the movable part of whose nose had been cut off in a duel, formed on both sides of the defect a rhomboid-shaped flap from the skin of the cheek, with its broad base at the margin of the defect. These two cheek-flaps were turned over toward the middle line, so that the wound surfaces which lay outward came together and were united by mattress suture. A flap from the forehead was then grafted upon these two (Fig. 182). The defects in the forehead and cheeks were covered by skin-grafts. The nose, which was at first very broad, was then made narrower by separating the lateral borders from the base, turning them inward and uniting them by suture in newly made incisions in the skin.

Fig. 181.—Serre's operation.

III. Rhinoplasty from the skin of the upper arm (Italian method,

after Tagliacozza [Taliacotius], sixteenth century) is only performed in exceptional cases, when there is no suitable material for rhinoplasty in the face. As has been said, Graefe revived this method again at the begin-

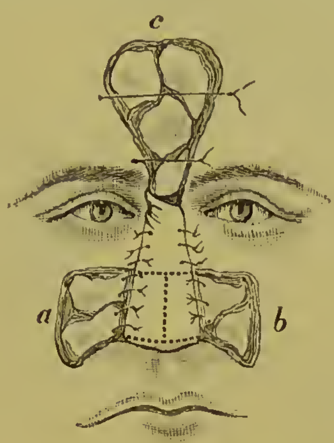


Fig. 182.—Thiersch's rhinoplasty.

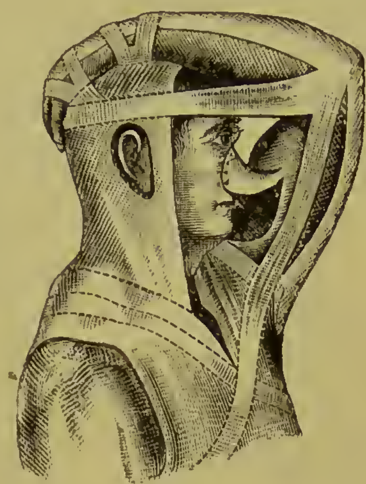


Fig. 183.—Italian method of performing rhinoplasty.

ning of this century, and simplified it. A pedunculated flap of skin of the right size is formed on the anterior surface of the upper arm, and its free base is sutured into the defect. While the flap is healing in place, the arm must be fastened securely to the head (see Fig. 183). After the flap has healed into the defect, the pedicle is severed and the rhinoplasty completed.

IV. Partial rhinoplasty has to do chiefly with replacing the sides of the nose, the alæ nasi, the tip of the nose, and the septum.

Fig. 184.—Formation of the ala nasi or side of the nose from the skin of the other half of the nose (Langenbeck).

The alæ nasi and sides of the nose may be formed by means of a narrow flap from the forehead, the method being analogous to that for complete rhinoplasty, or by means of a flap from the other half of the nose, after Langenbeck (see Fig. 184). The defect upon the sound side is immediately covered by skin-grafts.

One can also close smaller defects of the alæ nasi from the skin of the cheeks (Fig. 185), or from the skin of the dorsum of the nose (Fig. 186), with the pedicle on the cheek. One may also utilize the upper lip for constructing the alæ nasi and the septum (Fig. 187).

If the tip of the nose and the ala nasi are both wanting, W. Busch's method, which has just been mentioned, is very useful (Fig. 186).

Helferich replaced the tip of the nose and parts of the ala nasi by placing underneath as a foundation a flap from the left cheek and laying over it a flap from the right cheek. Julius Wolff formed the tip of the nose as follows: A tongue-shaped flap of skin and bone was formed from the bony remnant of the nose with its base below. The nose was divided into halves by two transverse incisions, and the lower of the two was drawn

FIG. 185.—Formation of the ala nasi from the skin of the cheek.

FIG. 186.—Formation of the tip of the nose and the ala nasi from the skin of the dorsum (Busch).

FIG. 187.—Formation of the septum.

downward with the tongue-shaped flap of skin and bone. The wound upon the dorsum of the nose was sutured together, and the apex of the flap was inserted into the lower part of the wound. The transverse incisions were then united by suture. The tip of the nose was thus formed without a cicatrix on the forehead or the cheek. J. Wolff recommends drawing down a flap of skin and bone, without turning it over, in treating "saddle-nose" also (see page 293) and in performing complete rhinoplasty.

The septum can be constructed in various ways (Fig. 187). One can utilize for this the median vertical furrow of the upper lip by dividing it in its entire thickness by means of two perpendicular incisions and turning it outward and upward together with the mucous membrane (see Fig. 187, 1). The mucous membrane which is turned outward finally becomes more and more like the external skin. One can also cut an obliquely placed flap from the upper lip (see Fig. 187, 2). This can be more easily turned so as to bring the skin on the outside. All flaps taken from the upper lip shrink a great deal. Finally, the septum may be constructed from the skin of the dorsum of the nose by cutting, after Hueter, a rather long rectangular flap, with its pedicle near the tip of the nose (see Fig. 187, 3). The periosteum of the nasal process is included in the flap, in order that the septum may be sufficiently solid. E. Hahn constructed the septum from a flap taken from the floor of the nasal cavity, consisting of mucous membrane, periosteum, and bone.

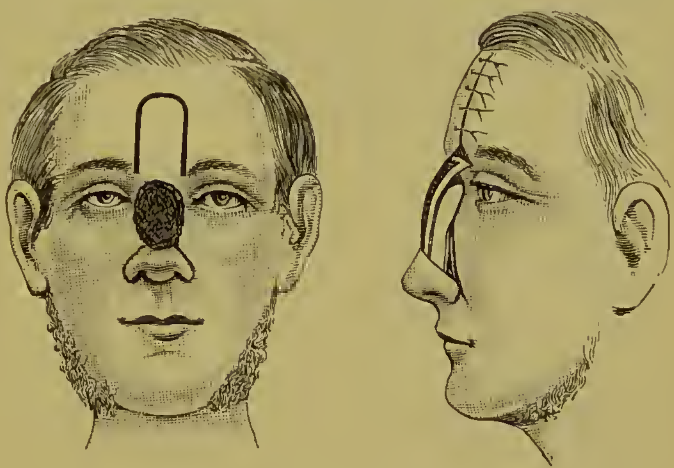
A few remarks may be made with reference to building up sunken

noses, especially those due to the destruction of the bones of the nose caused by syphilis or traumatism (syphilitic or traumatic "saddle-nose").

We have already mentioned in part the methods which may be here applied, such as, for example, the fashioning of flaps of skin and periosteum, the construction of a framework consisting of strips of bone taken from what remains of the bones of the nose, and the nasal process of the superior maxilla, after Langenbeck, the method of Hardie, etc. For the employment of a gold supporting frame, as recommended by Klein, Rust, Studjenski, and Krassin, see page 295. I will take up the following methods somewhat more in detail:

König has suggested a very practical method for building up a depressed nose when the bony part is entirely or almost entirely destroyed, and the movable part is tilted upward, by taking, as has been already mentioned, a flap of soft parts and bone from the forehead and laying over it a flap of skin.

König describes his method as follows: The soft part of the nose is first divided by a transverse incision at the deepest part of the depression and then drawn downward and forward. The gaping defect which thus arises is bridged over by an oblong flap of soft parts and bone three quarters of a centimetre to one centimetre broad taken from the root of the nose and the lower part of the forehead, and detached from the frontal bone with a chisel (Fig. 188 *a*). This flap of skin and bone with the bone surface turned outward is then sutured in such a way to the borders of the skin of the soft portion of the nose that the latter projects (Fig. 188 *b*). Over this framework of bone one now places a flap of skin from the frontal region and sutures it in place. Rotter uses König's method for complete rhinoplasty also, as has been mentioned, by forming a buttress-shaped framework for the nose from a frontal flap of skin, periosteum, and bone, which is covered over by skin grafting.



a *b*

Fig. 188.—König's rhinoplasty.

Israel has modified König's method in the following manner and with very good results:

He takes only a single quadrangular flap of skin, periosteum, and bone seven millimetres broad from the forehead, and this is turned downward for the formation of the dorsum of the nose, so that its bone surface is directed

forward. In this position it is sutured to the soft part of the nose which is separated transversely from the bone and drawn forward out of its depression. The wound in the forehead is closed by suture; the bone surface of the flap, in contradistinction to König's method, is not covered by a second flap of skin from the forehead, but left to undergo granulation and cicatrization. The skin on the posterior surface of the bone flap is drawn so far forward by this cicatrization that it finally covers two thirds of the entire circumference of the flap. The lateral walls of the nose which are still wanting are now formed from the opposed cutaneous coverings of the old depressed and the newly formed dorsum of the nose. After the latter has been drawn well to one side with a sharp hook, the skin of the old dorsum is divided by a median longitudinal incision, from the upper and lower ends of which transverse incisions run to both sides. After detachment from subjacent parts two quadrangular flaps are thus formed, which are to form the outer layer of the sides of the nose. For the formation of the inner layer, the lateral cutaneous coverings of the transplanted bone flap are detached from in front backward and the flaps of skin which are thus secured are turned backward so that their wound surface is directed outward. The flaps which were first formed are placed upon these supporting flaps and sutured to the new dorsum of the nose.

Israel has more recently modified or improved his method, which has just been described, as follows: 1. The connecting bridge of the frontal flap is cut through and inserted lower down, in order to secure the normal depression at the root of the nose. 2. The frontal flap is made to consist of skin and periosteum two centimetres broad with a ridge of bone in the centre of it which is only four millimetres broad, and the projecting skin on both sides is united by suture around the bone. In this way the nose is made narrower. 3. In order to form the dorsum of the nose of skin, not of cicatricial tissue, the incision is made to include still more skin, and the latter can be united over the ridge of bone when one later sutures the skin of the sunken nose to the side of the protuberance that is thus formed.

Ollier formed the framework of bone in treating sunken noses as follows: He first made a Λ-shaped flap of skin with the apex directed toward the forehead, the base of the flap retaining its connection with the alæ nasi and the septum. At the apex of the flap on the forehead the periosteum was included in the flap, but not elsewhere. A bone flap thirty-five millimetres broad was then removed with the chisel, on the right, consisting of the remains of the nasal bone and the nasal process of the superior maxilla with a pedicle of mucous membrane and periosteum. This flap was turned downward and pushed under that above mentioned. The apex of the triangular frontal flap was folded together in a vertical direction and united by catgut suture, and the flap was now displaced four centimetres downward and sutured to the wound margins of the cheek, after the soft part of the nose had been elevated as much as possible by dividing the cicatricial bands.

The method of Dieffenbach is also very practical in which several flaps are made to heal over one another at intervals.

Trendelenburg properly recommends Langenbeck's method very strongly. The lower, movable part of the nose is separated from the upper part by a transverse incision and the tip of the nose is drawn downward. A Y-shaped

flap from the forehead whose pedicle contains periosteum is laid into the semilunar transverse defect. The neighbouring skin from the nose and cheek is drawn over this flap later, after it has healed in its place and has been denuded of epidermis. In extreme cases of sunken nose the method of Mikulicz is also strongly to be recommended. The skin of the nose is separated from the cheek and, after it has been denuded, it is folded together from the sides toward the median line and united in this way by suture. Over this sort of nasal septum a frontal flap is then laid. Of late, Mikulicz adopts the principle, carrying out in part the method of Dieffenbach, of avoiding skin defects and correcting the depressed nose subcutaneously and subperiosteally with what remains of the old nose. By sliding the soft parts and the periosteum of the cheeks after subperiosteal detachment and by silver-wire plate sutures applied transversely through the base of the nose, the attempt is made to restore to the bridge of the nose its original height. By the introduction of wire arches into the nostrils or the application of nasal clamps, which press the lateral walls of the nose together, one attempts to retain the new form.

In less marked cases of sunken nose, where the bone and cartilage are in part retained, it is sufficient if one divides the skin of the nose, after Dieffenbach, in the median line, detaches the margins, and then takes a flap of skin from the forehead. The skin on the side is then pushed over this flap later. Or one may, after Bardeleben, take a flap of skin and periosteum from the forehead with the wound surface outward and draw over it, at the same sitting, the skin of the nose which has been detached on either side.

If the framework of bone has been preserved and the movable part of the nose has sunk in, one may raise up the nose, as has been said, by inserting a supporting apparatus of gold plate (Dieffenbach), of amber (Leisrink), or of metallic wire covered with India rubber (Mikulicz). (See also, above, the orthopædic treatment after Mikulicz). Dieffenbach divided the nose by two incisions into three perpendicular strips, which were then united by suture in a proper elevated position after the wound surfaces had been trimmed obliquely. They were kept in their elevated place by lateral compression by means of small perforated splints and an entomological needle stuck through transversely. The skin of the cheeks in the neighbourhood of the nose was freed somewhat, and likewise drawn inward by lateral compression. A permanent result, however, was not usually reached in this way.

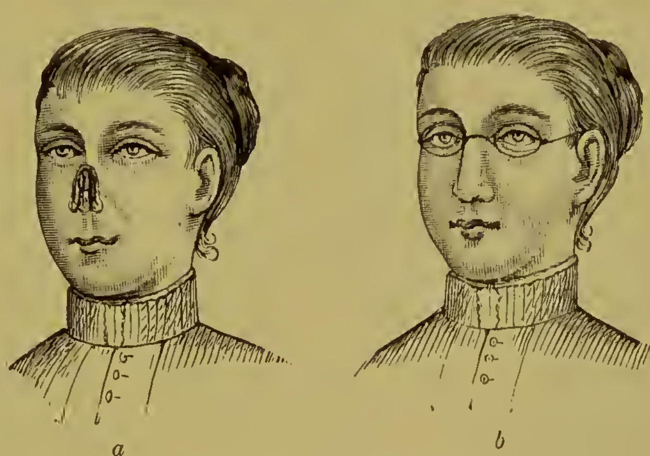


Fig. 189.—Artificial nose.

Rust, Klein, Studjenski, and Krassin have inserted with success, in cases of depressed nose caused by syphilis, a framework of gold through an inci-

sion in the naso-labial fold. This roof-rafter apparatus—e. g., of Studjenski and Krassin—consists of a wire ring fitting closely to the bony border of the apertura pyriformis and to be fastened by three platinum-wire sutures, and of a thin curved, perforated plate which is intended to bind the halves of the ring to each other and to insure to the dorsum of the nose its form and elevated profile. Aside from the three wire sutures, a slight horizontal incision on the mucous-membrane side of the tip of the nose also serves for keeping the apparatus in place. A thick-walled drainage-tube is introduced into each nostril for four or five weeks, in order to press the elevated nose against the supporting framework. The healing is by that time complete. Krassin gives a report of seventeen cases of depressed nose thus treated by Studjenski. The results were very satisfactory.

Matti Äyräpää (Helsingfors, Finland) corrected sunken noses by the use of plates of hard India rubber upon whose upper surface is mounted an artificial nasal septum. The apparatus is introduced through an opening in the hard palate. Äyräpää also uses elastic hollow cylinders of soft India rubber by which the nose is elevated, inasmuch as they press against the floor and the alæ of the nose.

Defects of the nose have been of late very successfully restored in part by artificial protheses of vulcanized India rubber, celluloid (Kleinmann), and of soft India rubber (Sauer). These protheses are held in place by a spectacle frame, for instance (Fig. 189), or by two pincer-like wires which spring apart.

CHAPTER VI.

INJURIES AND DISEASES OF THE JAWS.

Injuries of the Bones forming the Jaws: Fractures of the upper jaw.—Fractures of the malar bone.—Fractures of the lower jaw.—Gunshot injuries of the bones of the face.—Dislocation of the lower jaw.—Fracture of the glenoid cavity of the lower jaw, and of the anterior wall of the external auditory meatus.

Injuries and Diseases of the Teeth and Gums: Anatomy and physiology of the teeth.—Disturbances in the development of the teeth.—Caries.—Diseases of the pulp.—Periostitis of the roots and alveoli.—Parulis, or Gumboil.—Fistulæ.—Causes of toothache.—Tartar.—Discoloration of the teeth.—Fracture and dislocation of the teeth.—Replacement of teeth.—Tumours of the teeth.—Cleansing the teeth.—Diseases of the gums.—Extraction of teeth.

Inflammatory Processes in the Upper and Lower Jaws: Periostitis.—Osteomyelitis.—Caries.—Actinomycosis.—Necrosis.—Phosphorus necrosis.—Diseases of the antrum (dropsy, empyema).—Tumours of the upper and lower jaws.—Diseases of the temporo-maxillary articulation.—Resection of the temporo-maxillary articulation.—Trismus.—Resection (complete and partial) of the upper jaw.—Operations on the lower jaw.

Deformities: Fissures of the jaws. See §§ 25, 63.

§ 43. **Fractures of the Upper Jaw.**—Fractures of the upper jaw are due, as a rule, to direct violence—a fall, for example, the kick of a horse, the force of machinery, a bullet wound, or, as is frequently the case, to violence from within the mouth. Circumscribed fractures of the alveolar process occur most commonly during the extraction of teeth. They were more common when the so-called tooth-key was used in extraction.

Fractures of the body of the superior maxillary bone are, generally speaking, of rare occurrence, those of the alveolar process resulting from the extraction of teeth being more common. Very considerable force has generally been necessary to cause a fracture of the body. Now and then complete displacement of both superior maxillary bones has been observed (Wilbur).

Sometimes, as the result of a fall or a blow upon the upper jaw below the nose, transverse fractures of both superior maxillary bones occur and may extend through the canine fossæ to the pterygoid processes (Guérin). Fractures of the base of the skull occasionally extend

into the superior maxillary bone and sometimes even cause extensive shattering of the bones of the face, as, for example, in the case reported by Beck, shown in Fig. 190. In other cases the order is reversed, the fracture of the base of the skull being secondary to that of the upper jaw. Extensive comminution of the bone accompanies most fractures of the jaw, combined with injury to the skin or the mucous membrane. Fractures of the palate process alone are the most rare.

Fig. 190.—Fractures of the base of the skull extending into the bones of the face.

The symptoms of a fracture of the upper jaw differ greatly, according to its location and the amount of separation. They vary from the simple displacement of a part of the alveolar process to the shattering of one or both of the superior maxillary bones, with immediate death from simultaneous fracture of the cranium.

Since most fractures of the upper jaw are direct, a corresponding injury or swelling of the soft parts is generally present. The bones are tender on pressure, and abnormal mobility can be detected at the point where the break has occurred. The deformity also is very variable. In fractures of the anterior wall of the antrum, depression of the fragments is particularly well marked. An abnormal position of the teeth is especially frequent, as a result of which the teeth of the upper and lower jaw do not come together properly. Emphysema of the side of the face that is involved is noticed, especially in fractures that penetrate into the antrum, the nasal cavity, or the frontal sinuses. Exophthalmos sometimes occurs in consequence of hæmorrhage when fractures extend through the floor of the orbit, so that the more or less immovable eyeball is pressed forward. Hæmorrhage resulting from laceration of the internal maxillary artery is a serious complication in fractures of the upper jaw, especially in gunshot fractures, and, since the arrest of hæmorrhage is difficult in case of injury to this artery, the common carotid has been ligated several times, but without effect. The complications arising from simultaneous fracture of the base of the skull have already been mentioned. Of the nerves of the face, the infraorbital and facial are often injured in consequence of the direct violence, so that anæsthesia may occur in the region supplied by the injured infraorbital nerve, and neuralgia of the nerve may follow later as the result of pressure of the callus, or there may be paralysis of the facial nerve.

The prognosis of fractures of the upper jaw is, as a rule, good, if

the more serious complications, especially fracture of the base of the skull and rupture of the internal maxillary artery, are absent. Fractures heal rapidly by the formation of a bony callus, and even in case of extensive splintering, as a rule, no progressive suppuration occurs. The upper jaw has, in fact, a very marked regenerative power. Loosened teeth gradually become firm again, and, if the alveoli are still sufficiently deep, even those that have fallen out may become firmly fixed in position again if immediately replaced.

The diagnosis of fractures of the upper jaw is generally easily made from the symptoms above mentioned, as the bones can be well palpated.

The first step in the treatment of these fractures consists in overcoming any displacement that may exist, so that the teeth of the two jaws may come together properly. The funda maxillæ is a good impromptu dressing (Fig. 191), or a bandage of the nature of the capistrum duplex (Fig. 192). For information concerning the application of these bandages, the reader is referred to Principles of Surgery, pages 185–199. In case the anterior wall of the superior maxillary bone is depressed, it may be raised by means of a sharp hook, after making an incision through the overlying skin. Splinters of bone that are completely separated should be removed. Those that retain some connection with the bone and periosteum should be left as they are. To secure the fragments in their position, suture of the bone with catgut, silkworm gut, or silver wire is sometimes to be recommended. As a bandage for retaining the displaced pieces of bone in position, the funda maxillæ which has just been mentioned is often sufficient, or the capistrum duplex made with gauze bandages, plaster of Paris, or water glass, or strips of gutta-percha, as in fractures of the lower jaw (see pages 303 and 304). In mild cases the teeth may be kept in position by means of a metal wire passed through the edges of the bone at the seat of fracture. Similar interdental splints are used here as in fractures of the lower jaw. These will be described more in detail (see pages 304 and 305). It is well in more severe cases to consult a dentist with reference to the fixation of the fractured bone and in case a fracture has not united satisfactorily. Careful cleansing of the mouth by means of antiseptic mouth washes of chlorate of potash, permanganate of potash, or boric acid is important, especially when the mucous membrane is injured.

FIG. 191.—Funda maxillæ.

FIG. 192.—Capistrum duplex.

The patient should take only liquid food, and should talk as little as possible. Wounded parts should be treated with antiseptics and dressed in the usual manner. Operative measures, especially primary resections, formerly so much resorted to, should be avoided as far as possible (see pages 303 to 305, Treatment of Fractures of the Lower Jaw).

§ 44. **Fractures of the Malar Bone.**—Isolated fractures of the malar bone are very rare. They are generally found combined with fractures of the superior maxilla, especially its anterior wall, resulting from direct violence, and with fractures of the orbit. The complete loosening of the malar bone from all its connections is also called dislocation. The deformity from these fractures consists chiefly in a depression of the bone inward and toward the cavity of the eye, resulting from the fact that direct violence is almost always applied from in front and below. The most important and most common symptoms consist, therefore, in a flattening of the side of the face that is involved and in interference with mastication, the insertion of the masseter on the malar bone being affected. The masseter sometimes draws the broken malar bone downward. An outward displacement can occur in case of force applied from within the mouth. Exophthalmos may result in fractures through the orbital process of the malar bone in consequence of an effusion of blood within the orbit.

Fractures of the zygoma, notwithstanding its exposed position, are likewise of rare occurrence. They are due generally to direct violence either from without or within the mouth, and the displacement of the broken bone is accordingly in an inward or outward direction. As a result of the severe hæmorrhage, a marked swelling generally appears soon after the injury is received, so that the diagnosis of the fracture, if not seen at once, may be difficult. At the time of the injury, however, it is easily made by direct palpation and by inspection of the deformity of the zygoma. The act of mastication—that is, opening and closing the mouth—is also generally interfered with in fractures of the zygoma, because the deeper layer of the masseter arises from its anterior portion. The movement of the lower jaw can also be interfered with by the displacement of splinters of bone toward the coronoid process and by their penetration into the masseter and temporal muscles.

The treatment of fractures of the malar bone and zygoma consists at first in overcoming, as far as possible, any displacement that is found, the inward displacement, which is the most common, being corrected from within the mouth, and in retaining the bone in place, possibly by means of aseptic suture of the bone or periosteum. Sometimes, however, reduction is impossible. In suitable cases the site of frac-

ture may be exposed, with antiseptic precautions, the displaced bones forced into their proper position and held there by suture of the bone or periosteum. Even if the displacement is not corrected, the deformity often completely disappears after the fracture has healed, and the same is true of interference with opening and closing the mouth.

§ 45. **Fractures of the Lower Jaw.**—Of all fractures of the bones of the face, those of the lower jaw are the most common.

The following fractures of the lower jaw occur: 1. Fractures of the alveolar process. 2. Fractures through the horizontal portion or body of the jaw. 3. Fractures of the rami. 4. Fractures of the condyloid process. 5. Fractures of the coronoid process.

Here also fractures of the alveolar process are the most frequent. This was especially the case earlier, in consequence of the unskilled use of the "tooth-key." Fracture of the coronoid process is the most rare. Fractures of the body, especially in the region of the incisors and canine teeth, are more common than those of the ramus. Fractures through the body usually take an oblique course from in front backward, so that the fragments become displaced easily. Double fractures of the lower jaw are not very rare, and both fractures lie either symmetrically on both sides, or more or less unsymmetrically, one fracture, for example, running through the body and the other through the angle or the ramus.

The majority of fractures of the lower jaw are accompanied by wounds of the soft parts (compound fractures). Most frequently the mucous and periosteal coverings in the cavity of the mouth are opened.

The causes of fractures of the lower jaw are for the most part direct (kick, blow, fall). Indirect violence is the cause mainly of fractures of the condyloid process—e. g., a fall or blow upon the chin, which forces this process into the glenoid cavity. The latter can likewise be shattered (see § 9, Fractures of the Base of the Skull). Direct fractures of the condyloid process from a blow or kick upon the cheek are less common. Fractures of the body may also arise from indirect violence, when, for example, a wagon-wheel passes over the region of the angle of the jaw and the lower jaw is pressed together so that it breaks near the middle. Fractures of the same part are also said to have occurred from muscular action. Fractures of the ramus are, almost without exception, the result of direct violence, and occur most frequently near the angle of the jaw. Fractures of the coronoid process are also caused only by direct violence. The most important mutilations of the lower jaw result from gunshot wounds, from suicide by shooting into the mouth, and, above all, from grenades and from heavy projectiles in general.

The symptoms of a complete fracture of the lower jaw through the body and in the region of the angle are so plainly marked that the diagnosis is easy. All the subjective and objective symptoms of fracture are here present, especially pain, deformity, abnormal mobility, and crepitus. The pain is very severe, particularly when it is caused by laceration or crushing of the inferior dental nerve or its branches, the small nerves of the teeth. The deformity can be best recognised by examining the row of the lower teeth. In case of fracture in front of the masseter, the posterior fragment is generally drawn outward and forward by the masseter and temporal muscles—i. e., pushed forward more or less over the other, while the anterior fragment is moved inward and downward by the muscles passing from the chin to the hyoid bone (digastric, genio-hyoid, and mylo-hyoid). Exactly reversed displacements of the fragments also occur, all displacements depending upon the nature and direction of the force and upon the direction of the line of fracture. In fractures of the lower jaw behind the insertion of the masseter there is generally no displacement, because the fragments are held firmly by the masseter and internal pterygoid muscles. In case the body is broken in two places, there is generally a downward displacement of the middle fragment, simply from its own weight.

Abnormal mobility is, as a rule, greatest in the case of fractures of the body in two places.

The behaviour of the patient with a fracture of the lower jaw is very characteristic. He usually supports the broken jaw with the hand when he attempts to speak or to swallow, and keeps it as still as possible. Saliva flows from the open mouth and speech is indistinct. The loss of blood is not serious and is caused mainly by the laceration of the mucous membrane of the gums.

If the condyloid process is fractured it is drawn inward and forward by the action of the external pterygoid muscle, while the rest of the jaw inclines to the fractured side on account of the shortening of the broken process. In case of fracture of the condyloid process on both sides, the lower jaw is often pushed backward, so that the lower teeth are behind those of the upper jaw. There is generally great difficulty in the reduction of the fractured condyloid process and its subsequent retention. The most serious complications are fractures through the glenoid cavity or base of the skull with concussion of the brain and injury to the organ of hearing, combined with bleeding from the ear (see also pages 309 and 310).

In fractures of the coronoid process the displacement is, as a rule, insignificant. Even if completely broken off, it is seldom drawn up-

ward by the temporal muscle, because the points of insertion of the tendinous fibres of this muscle extend well downward, and consequently hold together the fragments more or less.

The repair of all fractures of the lower jaw takes place, as a rule, by means of a bony callus. It is generally slow, requiring, in complete fractures of the body and angle, from four to six and even ten weeks. In compound fractures, suppuration is generally slight in spite of the presence of catarrhal inflammation of the inside of the mouth. Necrosis is usually only partial, but if the entire thickness of the bone is affected, which seldom happens, there is a corresponding permanent deformity, so that the teeth do not meet properly.

Pseudarthrosis is rare, occurring, according to Norris, in only two cases out of one hundred and fifty. It is comparatively most frequent when there is a sequestrum or a tooth between the fragments. In case of pseudarthrosis, the union of the fracture is either absent altogether or is fibrous. If it is in the body of the jaw, mastication is usually disturbed, and even if farther to one side in the region of the angle or ramus, biting hard food and chewing are more or less interfered with.

Treatment of Fractures of the Lower Jaw.—In fractures of the body of the lower jaw the treatment consists, first, in overcoming any displacement that has occurred, so that the teeth may come together well. If reduction of the fragments is attended with difficulty, it should be done under an anæsthetic. Just as in milder cases of fracture of the upper jaw, so here a bandage of the nature of the funda maxillæ or the capistrum duplex, made of gauze, plaster, or water glass, to keep the upper and lower teeth in firm contact, often suffices for holding the parts in position after they have been replaced. These bandages are especially to be recommended as first-aid bandages. Bouisson's bandage, shown in Fig. 193, which is easily put on and removed, may also be used.

Fig. 193.—Bandage for fractures of the lower jaw (Bouisson).

Gutta-percha splints are also well adapted to the purpose. Gutta-percha is softened in hot water and then laid and moulded about the lower jaw. When the splint has hardened, it can be covered with gauze inside and then fastened on with bandages in the way described above. Genzmer recommends that strips of gutta-percha half a metre long and as wide as the hand be softened in hot water, then placed

with the centre upon the chin and carried around the angles and rami of the jaws, then brought in front of the ear to the top of the head, and here crossed. To prevent the strips from adhering to each other where they cross, linen may be placed between. The strips are finally secured in place by bandages.

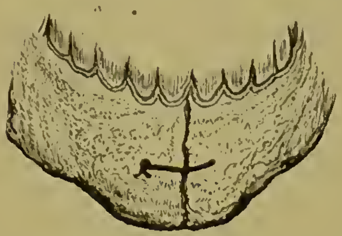


Fig. 194.—Suture of a fracture of the inferior maxilla.

In those fractures of the lower jaw in which there is difficulty in retaining the replaced fragments in position—when, for example, there is extensive splintering, or a double fracture, or the line of fracture is very oblique—special methods for retention must be resorted to. Some have simply wound silver wire about the teeth; but this is not a good plan, because the teeth are in this way loosened, the gums are irritated, and, after all, the parts are not firmly held. Suture of the bone with silver wire, though usually unnecessary in simple fractures, is the best treatment for compound fractures. In performing this, the gum is divided on the labial and lingual surfaces of both fragments of the jaw, holes are made with a drill,

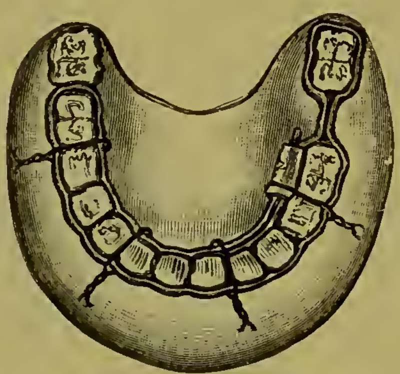


Fig. 195.—Sauer's interdental splint of aluminium-bronze wire.


Fig. 196.—Kingsley's interdental splint of vulcanized rubber with clasps of steel.

and the pieces are fastened with silver wire (see Fig. 194). An external bandage, with or without a gutta-percha splint, should then be applied.

Instead of external splints, or, in addition to them, interdental splints of metal, gutta-percha or vulcanite are to be strongly recommended, especially in cases where the fragments tend to become displaced. An interdental splint of gutta-percha is most simply prepared by moulding softened gutta-percha about the teeth, and then letting the patient press the jaws firmly together. These splints are very effective. The best way, however, is first to take a plaster model of the jaw and then prepare the splints of gutta-percha or vulcanite from this. Sauer has

recently recommended interdental splints of aluminium-bronze wire, which are also carefully made from plaster models, so that they closely conform to all depressions and projections of the teeth. They are fastened by means of several thin wire loops which pass between the teeth (see Fig. 195). These splints closely resemble Hammond's, which are made simply of iron wire and laid about the teeth. Angle uses thin bands of silver in the form of closely shutting rings for holding the parts in place. These are laid about two sound teeth which are not too far apart, and then firmly joined together. Hamilton speaks highly of the interdental splints of vulcanized India rubber with two clasps of steel wire running outward toward the angle of the jaw, which were devised by the American dentist Kingsley (see Fig. 196). This apparatus is also fastened from the outside by means of a bandage passing under the chin from one clasp to the other.

In bad cases it is well to consult a skilful dentist and have an interdental splint of gutta-percha, vulcanite, or aluminium-bronze wire prepared from a plaster model of the jaw. Dental science has made satisfactory results possible even in very unfavourable cases. The dentist Sauer, for example, has been very successful in the treatment of fractures of the lower jaw which had united badly (see Vierteljahrsschrift für Zahnheilkunde, xxi, Heft 3 and 4). Suersen has gradually straightened badly united fractures by means of carefully elaborated interdental splints which were adjusted accurately to the fragments and forced apart by wedges.

It is always extremely important that the patient should open his mouth as little as possible, and should take only liquid food. This he can draw in through openings between the teeth or through the space behind the last molar tooth, a long tube being used. Mastication should not be allowed for five or six weeks. The mouth should be frequently cleansed. Any suppuration that occurs must be carefully treated, and necrotic bone is not removed until it has separated or become demarcated.

In fractures of the condyloid process the attempt may be made to overcome the displacement from within the mouth, but this is difficult, and it is still more difficult to retain the parts in place. The bandages which have been described above are suitable for use here also.

Claude Martin has successfully used for fractures of the lower jaw two splints, one being placed along the line of the teeth, the other along the border of the jaw, and the two united by a spring. The lateral portions of the outer splint are fitted with hinges and connected with the middle portion in such a way that when the dressings are changed, in a case of compound fracture, for example, they can be turned down out of the way. The inner

splint must be prepared by a specialist from a plaster model. It is made of fine sheet steel. This material is so thin that two splints or layers can be placed upon the teeth. To allow for cleaning, openings are made in the splint corresponding to the eminences of the teeth. The centre of this splint is connected with the outer one by means of a spring-catch.

Pseudarthroses of the lower jaw are treated in accordance with general rules (see Principles of Surgery, page 603). The removal of a sequestrum or a tooth that has been wedged in between the fragments is often necessary. It is best, as a rule, if the functional disturbance is considerable, to freshen the fragments and unite them by suture of the bone.

Gunshot Injuries of the Bones of the Face.—We have repeatedly spoken of gunshot injuries of the bones of the face in treating of fractures of the upper jaw and malar bone, so that only a few words are here to be added by way of summing up.

Gunshot injuries of the bones of the face are not frequent. In none of the recent wars have they amounted, according to Albert, to more than twenty-five per cent of the whole number of injuries. In peace they are confined almost exclusively to gunshot wounds from within the mouth, inflicted by suicides. In these cases marked swelling ensues and both jaws may be shattered. The greatest mutilations are caused by bombs and the like. I treated a French soldier in the Franco-Prussian War, the greater part of whose upper and lower jaws had been so torn away by a grenade that the mouth was changed into a huge cavity. After partial recovery the patient was removed to a French hospital, and I have been unable to learn whether his recovery was complete. If the antrum is entered, it occasionally happens that the ball remains there for a longer or shorter time. In treating of injuries to the skull we have already emphasized the difficulty of arresting hæmorrhage from the internal maxillary and the deep temporal arteries caused by a gunshot wound in the region of the temporal and spheno-maxillary fossæ. Secondary hæmorrhage is here also greatly to be feared. and when it can not be arrested by compression and styptics, nothing remains but to ligate the carotid, or tie these arteries at the seat of the injury, by resecting the ramus of the lower jaw. Primary resections of the jaw which were formerly so often performed in treating gunshot wounds of the bones of the face are very properly no longer customary. These wounds are to be treated antiseptically and as conservatively as possible, according to general rules. Particular attention must be paid to possible hæmorrhage, to suitable nourishment (by means, it may be, of the stomach tube), to cleansing the mouth, etc. Tracheotomy may be necessary on account of œdema of the glottis.

§ 46. **Dislocation of the Lower Jaw.**—Dislocation of the lower jaw occurs, almost without exception, from behind forward (Fig. 197). It is caused by the slipping forward of the condyloid process over the eminentia articularis of the glenoid cavity. This may happen when the mouth is opened widely, in gaping, for example, screaming, vom-

iting, for the extraction of a tooth, or the introduction of a stomach tube. It may also be caused by a kick or blow from without when the mouth is open, or, again, by force from within the mouth. After the condyle has slipped forward, it is firmly held in front of the eminentia articularis by the tense lateral ligaments and the masseter and external pterygoid muscles. The coronoid process also becomes caught sometimes in the temporal and masseter muscles, and this circumstance may contribute to the fixation of the dislocated jaw. There is, as a rule, no rent in the capsule, Maisonneuve maintaining that it never occurs. This is the only complete traumatic dislocation without a rent. The accessory ligaments also, especially the internal lateral and stylo-maxillary, do not become ruptured as a rule.

Fig. 197.—Forward dislocation of the lower jaw.

As regards the anatomy of the temporo-maxillary articulation, it should be remembered that there is an interarticular fibro-cartilage between the glenoid cavity and the condyle, whose upper surface is conformed to the eminentia articularis of the temporal bone and the under surface to the articular surface of the condyloid process of the lower jaw. The capsule of the temporo-maxillary articulation is intimately blended with the edge of this interarticular ligament, so that there are two joint cavities, an upper and a lower.

Dislocations of the lower jaw are, generally speaking, rare, forming, according to Albert, but one and a half per cent of all the dislocations that occur. They are more frequently bilateral than unilateral. According to Malgaigne, fifty-four out of seventy-six were bilateral. It is a characteristic of these dislocations that they are more frequent with women than with men. Sometimes the dislocation is habitual—that is to say, there are some persons in whom it occurs more or less frequently as the result of comparatively trivial force. Such persons are obliged to be constantly on their guard against opening the mouth very wide. This habitual dislocation is sometimes the result of defective development of both jaws, with projection forward of the lower jaw (F. Heuckeroth). This defective development of the jaws is also noticed after premature loss or extraction of the milk teeth, particularly the molars.

The symptoms of bilateral forward dislocations are so characteristic that they are recognised at first glance (Fig. 198). The mouth is opened and can not be closed again. It is usually not so widely opened as in

Fig. 198, but only half way. The chin, teeth, and angles of the jaw are pushed forward correspondingly. The jaw is held fast in its abnormal position, the cheeks are flattened and lengthened, a corresponding depression is felt in front of the tragus, in the situation of the temporo-maxillary articulation, and in front of this is the condyloid process.

When but one side is dislocated the symptoms are not so marked. Here again the half-opened mouth can not be closed. The chin is pushed toward the uninjured side, and it is only on the dislocated side that one feels the depression at the site of the temporo-maxillary articulation and the condyloid process, which has been pushed forward.

The treatment of these dislocations consists in their reduction in the following manner: The patient sits in a chair and his head is firmly held by the hands of an assistant placed on both sides in the vicinity of

Fig. 198.—Bilateral forward dislocation of the lower jaw.

Fig. 199.—Reduction of a dislocation of the lower jaw.

the ears. The head should be turned a little upward. The surgeon, standing in front of the patient, then seizes the lower jaw in such a way that both thumbs are laid upon the molar teeth, while the other fingers clasp the jaw outside and underneath (see Fig. 199). The jaw is then pressed downward with the thumbs, the chin somewhat raised, and the jaw simultaneously pressed backward. The thumbs must be quickly withdrawn from the mouth, or they may be bitten when the jaws snap together. If the object is not accomplished in this way it is well, in case of bilateral dislocation, to attempt reduction first on one side and then on the other. The coronoid process is sometimes firmly caught, in which case one should try to accomplish the reduction by pressing the coronoid process backward. Success is sometimes easily attained in this way (Maisonneuve, Nélaton, Busch).

Immediate success generally attends the method first mentioned, but there are cases in which even experienced surgeons fail. These are usually dislocations that are complicated by a narrow rent in the capsule or by fractures. In these severe cases the patient should be anæsthetized. If reduction can not then be accomplished, the site of the dislocation must be exposed aseptically, and after the obstacles have been removed reposition will be possible. Resection of the condyloid process has also proved successful. A similar course should be taken in treating old dislocations.

One case of habitual dislocation, which had recurred about three hundred times within a year, was permanently cured by Genzmer by injections of the tincture of iodine. Patients with habitual dislocation often bring the jaw back into place themselves by the proper manipulations. Sometimes even a first dislocation is treated by the patient himself, or by one unacquainted with surgery, the reduction being accomplished by a blow upon the chin.

After the condyle has been successfully brought back into place, the lower jaw should be firmly held against the upper jaw by means of a bandage, and the patient should take liquid food only. For some time afterward care must be taken not to open the mouth too wide, as a recurrence easily takes place, and the dislocation may become habitual.

In case a dislocation of the lower jaw is not reduced, functional disturbances are generally somewhat alleviated spontaneously, so that the jaw becomes movable and the patient can chew with the molars. The forward displacement, however, or, in case only one side is dislocated, the lateral displacement, usually persists. The mouth can not, as a rule, be entirely closed. Complete spontaneous reduction seldom occurs.

Rare cases are found of backward dislocation of the lower jaw (retroglenoid luxation), with or without fracture of the anterior wall of the meatus. This may result from a kick, for example, or a blow upon the chin when the mouth is closed.

The symptoms of backward dislocation of the lower jaw, complicated by fracture of the anterior wall of the external auditory meatus, are a corresponding narrowing or complete occlusion of the meatus, bleeding from the ear, and escape of a sero-mucous fluid from the tympanic cavity, giving rise, perhaps, to the diagnosis of fracture of the base of the skull, accompanied by the escape of cerebro-spinal fluid. The mouth is likewise partially opened, but the lower teeth are behind the upper ones. Isolated fracture through the glenoid cavity and anterior wall of the external auditory meatus, without simultaneous dislocation of the jaw, also occurs (see § 9).

Still more rare are simple backward dislocations and subluxations of the lower jaw without simultaneous fracture (Croker, King, Thiem, F. Steiner). F. Steiner has collected from literature fifteen cases of backward dislocation and subluxation of the lower jaw. This dislocation arises from gaping, from violently pressing the teeth together, from spasmodic contraction of the temporal muscle, from a fall or blow upon the lower jaw, etc. In these simple backward dislocations the condyloid process of the lower jaw rests behind a small tubercle (tuberculum tympanicum) on the inferior wall of the external auditory meatus in front of the mastoid process, and external to the styloid process. This cavity (the fossa tympanico-stylomastoidea), in which the dislocated condyle rests, is, according to Thiem, much more roomy in women than in men. Complete dislocation is therefore almost impossible in the male sex, though two cases have been observed (F. Steiner).

Backward dislocations are reduced by drawing the lower jaw forward and downward, and by simultaneous pressure upon the condyle in the same direction. If the dislocation is bilateral, reduction is made first on one side and then on the other. The fragments that are displaced in the direction of the external auditory meatus are brought into their proper position by means of dressing forceps or the like, and then the meatus is packed with sterilized iodoform gauze. Anchylosis of the temporo-maxillary articulation has sometimes resulted, and this is best remedied by resection of the condyloid process.

§ 47. **Injuries and Diseases of the Teeth and Gums.**—Before speaking in detail of the diseases of the teeth we shall review certain anatomical and physiological facts relating to the teeth, a knowledge of which is absolutely necessary in studying the pathology and therapy of these diseases.

Man has, as is well known, thirty-two teeth ; but since the last molars—the wisdom teeth, so called—are often wanting, it is more correct to give from twenty-eight to thirty as the average number.

Each tooth consists of the *crown*, which projects into the mouth ; the *neck*, which is inclosed by the edge of the gum ; and, lastly, the *root*, embedded in the alveolus. The teeth of each jaw are divided, according to their form and position, into four incisors, and on each side one canine, two bicuspids, and three molars. The last of the molars is the wisdom tooth, so called. The canines, on account of their position below the eye, are also called eye-teeth, and the laity very often falsely attribute diseases of the eye to their extraction.

Each tooth is composed, first, of the enamel ; secondly, of the tooth substance proper, the ivory or dentine ; thirdly, of the cement ; and, fourthly, of the pulp (see Fig. 200). As is seen from the accompanying illustration, the enamel covers the crown of the tooth, grows thinner as it approaches the neck, and then ceases with a sharply defined border. The enamel consists of minute hexagonal rods, which converge toward the axis of the tooth. The

outer surface of the enamel is covered with a structureless membrane, which is a product of the connective-tissue dentinal sac and the membrana præformativa, which is epithelial in origin.

Dentine forms the body proper of the tooth. It consists of dental tubuli, which run from the pulp cavity to the periphery, and there divide and anastomose with one another. The dental tubuli contain the dentinal fibres or fibrillæ. Between the dentine and the cement is the globular layer, so called, which consists of spherical bodies with free spaces between, the so-called interglobular spaces.

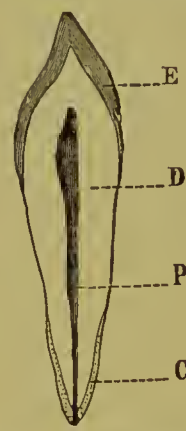


FIG. 200.—Longitudinal section of a tooth: *E*, enamel; *D*, dentine; *P*, pulp-cavity; and *C*, cement.

The cement forms the outer layer of the root. It begins on the neck of the tooth and grows thicker as it approaches the root. It is the softest part, and consists, like bone, of concentric lamellæ and bone cells. The cement forms during the entire life, whereas the dentine and enamel do not. The latter are to be regarded as completed structures.

The pulp is the tooth's organ of nutrition and sensation. It consists of fibrillary connective tissue with interposed cells, mostly spindle shaped, and of numerous vessels and nerves. A distinction is made between the crown pulp and the root pulp, which extends into each root of the tooth. The outer layer of the pulp consists of odontoblasts.

The periosteum, or peridentium, lies between the alveolus and the root. It is connected with the pulp, the periosteum of the jaw, and the gum.

The gum (gingiva), the extension of the mucous membrane of the mouth, has a very rich blood supply, but a comparatively poor nerve supply. It surrounds the neck of the tooth.

The nerves of the teeth have their origin in the fifth cranial nerve, the upper teeth being supplied by branches of the infraorbital and the lower teeth by the inferior dental. The arteries for the upper and lower teeth come from the internal maxillary.

For the preparation of microscopic sections of teeth, together with the soft parts, Weil suggests that a part of the crown or root be removed, laid in Müller's fluid, then in a solution of chromosmic acid or bichloride of mercury, and hardened in alcohol.

Development of the Teeth.—The first rudiment of the teeth appears at about the fifth month of fœtal life, and consists in an aggregation of epithelial cells, the so-called dental ridge. The enamel germ (Kölliker) then pushes itself deeper and deeper into the substance of the jaw in the form of a solid mass of cells, and the connective-tissue papilla or dentine germ grows toward it. While the enamel germ and that of the dentine change into enamel, and dentine after the differentiation of their cells, the dentinal sac surrounds the rudimentary tooth in the form of a connective-tissue covering.

The first dentition—that is, the appearance of the milk teeth in the mouth of the child—is usually as follows: First come the central incisors of the lower jaw, when the child is from six to eight months old. From two to four weeks later the corresponding teeth of the upper jaw appear. The lower

lateral incisors follow somewhere from the seventh to the ninth month, and a few weeks later the upper ones. Somewhere from the twelfth to the sixteenth month the child cuts the lower anterior molars, between the fifteenth and the twentieth month the lower canines, and between the twentieth and thirtieth month the lower posterior molars. The corresponding upper teeth follow, in each case, in from two to four weeks. For a child to have the lower incisors at birth is a rare exception. Scheff mentions as examples Richard III, Mazarin, Louis XIV, and Mirabeau.

The number of temporary teeth is twenty. These should also be carefully cared for and treated.

The eruption of the temporary teeth is attended with a certain amount of pain and inflammatory irritation of the mucous membrane. When children are passing through the so-called "teething" periods there is sometimes considerable disturbance of health, but this has been much exaggerated. Diarrhœa, coughing, suppuration of the jaws and gums, diseases of the skin, systemic diseases, etc., have been erroneously attributed to the cutting of the teeth. I do not deny, however, that reflex convulsions may occur. It is well, sometimes, when the cutting is difficult, to lessen the irritation and help the eruption of the tooth by means of an incision.

The loss of the milk teeth and the appearance of the permanent teeth usually begin in the seventh year. As is well known, however, the permanent teeth are in process of development while the milk teeth are still present. The eruption of the permanent teeth begins with the appearance of the first permanent molar on each side behind the second temporary molar, first in the lower and then in the upper jaw. The other teeth appear in the following order, the lower teeth in each case appearing first: In the eighth and ninth year come the middle incisors, in the tenth year the first bicuspid, in the eleventh year the canine, in the twelfth year the second bicuspid, and in the thirteenth year the second molars. Then comes an interval. The last four teeth, the back molars or wisdom teeth, appear, as a rule, between the sixteenth and twenty-fourth year, sometimes much later. They often come only in part, on one side, for instance, and they are sometimes absent altogether.

The cutting of the wisdom teeth is sometimes accompanied by severe irritation (*angina dentaria*). It is often necessary to incise the sensitive mucous membrane which covers the tooth, or to remove it altogether by the use of the cautery.

Seventy-five per cent of all persons have trouble between their eighteenth and thirtieth years, according to Magilot, in cutting the lower wisdom tooth (third molar). This consists in inflammation of the mucous membrane, the gums and the periosteum, the tonsils, the pharynx, and the floor of the mouth (gingivitis, stomatitis, tonsilitis, pharyngitis, difficulty in swallowing [*angina dentaria*], periostitis, ostitis, etc.). In case of suppurative periostitis and ostitis, the wisdom teeth must be extracted. The difficulty in cutting the third molar always results from a disproportion between the size of the crown of the tooth and the amount of space left on the jaw. Inflammation ensues, which is intensified and extended by microbic infection, especially when the mouth is unclean, and suppuration may result.

Statements concerning the appearance of a third dentition in old age be-

long to the realm of fable. If an apparent third eruption takes place in later life, it is really only a delayed cutting of the permanent teeth.

The change from one detention to the other takes place as follows: The crowns of the permanent teeth grow upward, and by pressure cause absorption of the roots of the first teeth, so that the latter are loosened, and gradually pushed upward till they fall out of themselves.

Disturbances in the development of the teeth are manifold. I mention only the excessive and deficient formation of crown and root, bends and distortions of the same, coalescence with adjoining teeth, tumours (odontomata), anomalous position of the teeth, superfluous teeth, the formation of too few teeth, etc. Superfluous teeth are, as a rule, outside the regular row, though they may stand in a line with the others. Five or six incisors, for example, have been observed in the upper or lower jaw. Superfluous teeth also appear in connection with a cleft jaw, as the result of a splitting of the enamel germ. B. Sachs explains in this way the appearance of the third incisors in cases of cleft jaw. When the formation of the teeth is defective, the upper canine or the small incisors are likely to be absent, and, most frequently of all, one of the wisdom teeth is wanting. Sometimes the missing tooth is retained within the alveolus, either because it is abnormally situated or because the adjoining teeth are too near together.

Anomalous positions of the teeth are of great practical importance. They are generally due to lack of room, the jaw being too small. Sometimes the first teeth remain too long, or the misplaced tooth may be a superfluous one. When the jaw is too small, the entire row may, in extreme cases, be irregular, so that the teeth stand, here and there, behind or over each other, instead of being side by side. In such cases, certain teeth—a canine or a molar, for example—should be extracted, in order to make room for the others, especially the incisors. If the permanent teeth come crookedly, above or beside the milk teeth, the necessary ones of the latter should be extracted, and then the permanent teeth, with the aid, it may be, of the dentist, brought into place. I refer to text-books on dental surgery for information concerning the technique of bringing misplaced teeth into position by pressure and traction.

Caries of the Teeth.—Of the diseases of the teeth I mention first, as most important, caries—that is, the progressive destruction of the enamel, above all, of the dentine, and least of all, of the cement. Caries always begins on the surface of the tooth, especially in the region of the neck and in the grooves of the crown. Gray-white, black, or greenish spots usually form at first. After destruction of the enamel rods the work of destruction extends to the dentine and here gradually advances.

Caries is due mainly to the formation of an acid by the action of which the substance of the tooth is decalcified. It then softens and crumbles to pieces. According to Klebs, Miller, Th. David, and others, the final cause of caries is to be sought in the presence of microbes, especially the *Leptothrix buccalis*. As a matter of fact, the most varied forms of microbes are always found in connection with caries, and

mould fungi as well. Garten has cultivated twenty-four acid-producing micro-organisms from carious teeth. In addition to the acid-producing micro-organisms there is a second kind by which, in the later stage of demolition caused by caries, the decalcified material is removed. There were nine, according to Garten, out of the twenty-four acid-producing micro-organisms which liquefied gelatine—that is, which dissolved albumin. An erosion of the enamel takes place first, and then the dentine is attacked. Erosions of the enamel may also be caused by mechanical means. It is not yet known what special acid is most active in caries; probably several acids are concerned. According to Schlenker, the cuticula dentis is decomposed by pepsin and various acids—vegetable acids, for example. Several predisposing influences play, at all events, an important part in the development of caries. These are, especially, heredity, pregnancy, severe constitutional diseases, diabetes, for example, trophoneurotic disturbances, and, above all, uncleanliness. Hesse has observed a peculiar form of caries in the teeth of bakers, on the labial and buccal surfaces, resulting from breathing in sugar dust ("sugar caries"), which, by fermentation, changes into an acid that erodes the teeth. Caries in children, resulting from the use of the nursing bottle, is to be explained in the same way.

The symptoms of caries are partly objective, partly subjective. The objective signs are discoloration and progressive decay of the diseased tooth. The subjective symptoms usually appear only when the caries is more advanced. The tooth is generally sensitive first to differences of temperature. As the process approaches the pulp more actual pain is felt. The exposed dentine, bared of enamel, can occasion violent toothache, inasmuch as the exposed dentinal fibres within the dental tubules transmit to the pulp the effects of injurious influences from without, such as changes of temperature, mechanical and chemical irritation, and especially sweetness or acidity of the food. Later, however, the exposed dentine is less sensitive because the dentinal fibres and dental tubules are destroyed and the communication with the pulp is interrupted. If the pulp cavity is opened and exposed to the air, the pain may be excruciating. After the opening of the pulp cavity there often ensues, in consequence of the presence of pathogenic microbes, suppurative inflammation of the pulp (purulent pulpitis), which may extend to the periosteum of the root and alveolus and to the outer side of the jaw. In the latter case a so-called alveolar abscess ensues. The diseased tooth must then be removed, as otherwise a fistula results and progressive necrosis of the bone may follow. Spreading suppurative processes of this kind not infrequently break through into the antrum of Highmore and give rise to empyema of the latter. I

once operated upon a very extensive empyema of the antrum caused in this way, accompanied by partial necrosis of its walls. The patient was in great danger of death from pyæmia because the dentist had not provided sufficiently for the escape of the great amount of pus that had collected and of the sequestrum. In another case I saw a septic phlegmon of the neck result from an alveolar abscess. I was called too late. The patient died of sepsis on the second day of treatment, in spite of free incisions and drainage. Extensive suppurative inflammation was found in the lungs.

In the majority of cases progressive suppuration does not attend caries, but a chronic, non-suppurative inflammation with the formation of granulations, as a result of which the pulp is more or less shut off. Thus by obliteration of the contents of the pulp cavity teeth may be lost without pain. This chronic, non-suppurative inflammation may, however, at any moment, in consequence of microbic infection, lead to acute exacerbations.

The course and prognosis of caries are good if it is discovered early, while the pulp and periosteum are still intact. If the pulp cavity has been opened, the suppurative inflammation that has been described may follow. The course of caries is, as a rule, slow; sometimes, however, it is more acute and reaches the pulp in a comparatively short time. A tooth thus affected is always a source of danger to the neighbouring teeth, caries being, so to speak, of an infectious nature. Hence it is that the process is often found to affect the adjoining surfaces of two teeth. It is on this account all the more important that caries should be discovered early and treated.

The treatment of caries of the teeth should first of all, if possible, be conservative. Only in extreme cases, when the process is far advanced, should the diseased tooth be removed. To check the progress of caries and to furnish a substitute for the destroyed substance, resort should be had, first of all, to filling the cavity with certain materials. The German words *plombiren* and *plombe*, which are used in this connection, are derived from plumbum (lead), which was formerly much used for filling.

The Technique of filling Teeth belongs to the province of dentistry, and the reader is referred to text-books on this specialty. The following brief remarks will suffice here: The softened substance of the tooth is removed by instruments adapted to cutting and boring, and the cavity is prepared for the filling. The materials most used for fillings are amalgam, cement, and gold. By amalgam is meant a combination of one or several metals with mercury. The substance thus formed quickly hardens. The amalgams most used at present contain gold, silver, and tin. The cements that are used are semi-metallic, consisting of zinc oxide and a chloride-of-zinc solution. They are

not so durable as amalgam and gold, but they are less noticeable, as they can be made to correspond with the tooth in colour. Gold is used in the form of gold foil (gold leaf) and as crystal or sponge gold. Gold is expensive, it is true, but it is a most excellent and durable material for filling. It can be used only for cavities whose walls are strong enough to stand the pressure which is necessary in filling with gold. Tin foil is, so far as I know, little used at present, and lead foil not at all.

Tin foil is inserted in the same manner as the soft gold material, but with less pressure. It fits itself admirably to the walls of the cavity, and, on account of its cheapness, is well suited for the use of beginners who wish to learn the art of filling with gold.

Hill's filling is a preparation of gutta-percha, used either as a temporary filling or to protect teeth which are very sensitive from the action, for the time being, of injurious influences from without. If the pulp cavity has been opened as the result of caries, it should, if still unaffected, be covered with a "cap," and the filling placed over this. If, however, the pulp cavity is already diseased it should be destroyed by the use of caustics (so-called "killing the nerve"), cleaned out, and filled. Teeth thus filled, though without a pulp cavity, may perform their function for a long time.

Diseases of the Pulp Cavity.—One of the most frequent causes of toothache is the opening of the pulp cavity as the result of caries, and its consequent exposure to the action of harmful influences from without, especially that of microbes. However, as we have already seen, the dentine, exposed through the loss of its enamel, may, by means of the dentinal fibres in the dental tubuli, carry over to the unexposed pulp the effects of injurious influences (differences of temperature, mechanical and chemical action), and also occasion pain. This is especially true of the exposed dentine at the neck of the tooth (where there is no enamel), when the gum recedes in consequence of absorption of the alveolar process. The pain in this case is very characteristic. It begins suddenly, the moment the injurious influence is at work, and ceases simultaneously with the disturbing cause. The dentine loses its sensitiveness later, as has been said, because the shrunken dentinal fibres and dental tubules no longer transmit the effects of the disturbing influence to the pulp cavity. When the pulp has been exposed in consequence of caries, and is not shut off by the formation of granulations, it frequently becomes acutely inflamed, partly from microbic infection and partly from purely chemical irritation. Inflammation of the pulp sometimes occurs also in teeth that have been filled, in consequence, for example, of the breaking through of its very thin covering.

Acute inflammation of the pulp (acute pulpitis) is characterized by very severe pain, which is frequently not confined to the diseased tooth, but spreads to the neighbouring teeth and to all the branches of the fifth nerve of the

affected side of the head, or even of the entire face. In this case a careful search for caries must be made with the mirror, especially upon the surfaces that are in contact, in order to find the right tooth. Sometimes the inflamed and swollen pulp tissue bulges out. The pain may, moreover, be caused by tumours in the pulp cavity without the appearance of anything abnormal on the outside.

Acute pulpitis may pass into the chronic form, which runs its course with little or no pain. In other cases this is the form in which pulpitis begins, and it may or may not be attended with painful exacerbations. Teeth affected by caries may thus wholly disappear without pain. Occasionally polypous, vascular outgrowths of the pulp protrude into the mouth. This happens, for example, in decayed molars, chewing being frequently interfered with. The tooth must be extracted in such cases, if it can not be filled.

Pulpitis, in other cases, goes on to suppuration (purulent pulpitis). The amount of pus is very variable, and the suppuration often spreads, as has been already said, to the periosteum and gum.

Treatment of Pulpitis.—The first indication in the treatment of pulpitis is to relieve the pain. To this end narcotics are used. Morphine, chloroform, or tincture of opium are dropped upon a piece of cotton and put into the diseased tooth. Popow recommends a one-twentieth-per-cent solution of permanganate of potash as very effective in toothache. Better than this is a thorough disinfection of the pulp cavity by the application of arsenic paste and pure carbolic acid. Arsenious acid works very quickly, with or without carbolic acid. Arsenic paste generally consists of one part arsenious acid, three parts morphine, and a little creosote. The tooth is deprived of its sensitiveness (so-called "nerve-killing") by pressing into the cavity a bit of this paste about as large as the head of a pin. As a protection against outside influences, cotton, or, better, wax or tooth resin (a solution of mastic in ether or of sandarac in alcohol) may be used. The pain is increased by the action of arsenic paste and carbolic acid, but it soon disappears. Good results also follow the use, first, of a mixture of carbolic acid and tannin, and then of arsenic paste (Witzel). According to Scheff, arsenic paste should be used when the exposed pulp is inflamed as a whole, but in milder cases, when the inflammation affects only a part of the pulp, he prefers carbolic acid. The treatment with carbolic acid or arsenic paste may be repeated after a day or two if necessary.

After the inflamed pulp cavity has lost its sensitiveness, in consequence of the application of carbolic acid or arsenic paste, it is carefully exposed and cauterized and, after the removal of the cauterized part, "capped" with a protecting cover—e. g., with phenol cement. Over this is placed the filling of amalgam or other material. Any exposed pulp cavity, though it be not inflamed, should be covered in this

way, as a protection against the pressure of the filling. Where there is a general inflammation and suppuration of the pulp, the latter should be entirely removed by the use of arsenic paste, and the tooth then filled, after careful disinfection of the entire pulp cavity within.

If a pulpitis has led to an alveolar abscess, the tooth must be extracted as soon as possible.

For tumours of the pulp cavity, see page 322.

Brief mention should here be made of the fact that with increasing age the pulp cavity, as a rule, constantly becomes smaller, in consequence of proliferation of the dentine. Calcification and fatty and colloid degeneration of the pulp are also sometimes observed.

Dental and Alveolar Periostitis.—The periosteum of the roots and of the alveoli are in close contact. They are both well supplied with vessels and nerves, so that when inflamed they cause great pain. Acute periostitis occurs especially after inflammation and suppuration of the pulp cavity, caused by caries; or the reverse may take place, acute inflammation of the gum and acute periostitis appearing first, and then extending secondarily to the pulp cavity.

It is characteristic of acute periostitis that the teeth, in consequence of the infiltration and exudation in the alveoli, are, as it were, lifted out. The patient asserts that one tooth is longer or higher than the others. The pain is increased by touching the tooth and by chewing. If suppuration results, there may be a considerable rise in temperature. There are several directions in which the pus may work its way outward—e. g., along the periosteum of the root and neck of the tooth, or through the alveolar process and gum. Before breaking through the gum, the pus generally collects in the form of a larger or smaller abscess between the bone and the mucous membrane (alveolar abscess or parulis). In case of extensive inflammation and suppuration, especially of the molars, in the neighbourhood of the wisdom teeth, inflammatory lockjaw results, as a rule, so that the mouth can only be opened under anæsthesia by the use of Roser's or Heister's mouth gag. After the abscess has opened spontaneously or with the aid of an incision, a corresponding amount of pus is evacuated. Not infrequently, as we have seen, extensive suppuration follows a periostitis, which may break through into the antrum or into the spheno-maxillary fossa as far as the base of the skull, followed, it may be, by a fatal meningitis, septicæmia, or pyæmia. A resulting deep abscess of the neck may also, as we saw above, cause a fatal result.

In cases of suppurative inflammation of the root of the tooth a fistula often remains, after the pus has broken through the mucous membrane of the mouth or through the outer skin, which only closes after

the extraction of the diseased tooth or root. These fistulæ sometimes perforate the skin near the orbit and at the inner canthus, and can easily be mistaken for fistulæ of the lachrymal sac. A fistula of this kind in the cheek may, at first glance, be mistaken for one from the salivary duct. In other cases the suppurative process descends toward the neck and points there. Nicolai observed a fistulous opening of this sort on the chest. The diagnosis is usually easily made by the use of a probe. The probe always leads to the diseased tooth.

Not infrequently necrosis of the alveolar process results which is usually circumscribed. Since the maxillary bones are very vascular, an apparently well-developed necrosis often disappears entirely.

Chronic suppuration of a more or less clearly defined tubercular character is sometimes observed.

Complete return to the normal may occur at any stage of an acute periostitis, even without the formation of pus. Most frequently, however, suppuration follows, with a discharge of pus externally.

The treatment of periostitis consists, in the beginning, before suppuration is present, in painting the gum with tincture of iodine in the neighbourhood of the diseased tooth, and in an incision for drawing off the blood. If a filled tooth is the seat of the inflammation, the filling must be removed. If the pain continues, the case is probably one of suppurative periostitis. If suppuration does take place and an abscess forms, extraction of the diseased tooth is indicated, and, in addition to this, the abscess should be opened and cleansing mouth washes of boric acid, chlorate of potash, or permanganate of potash used during the next few days. If there is retention of pus, the edges of the abscess cavity must, if adherent, be separated again by means of a probe. In case the suppuration spreads in the direction of the upper jaw or the neck, liberal incisions must be made, and, in fact, wherever pus is found it should be given a free exit. In case of empyema of the antrum, the latter should be opened and drained, access being gained either from a fistula in the alveolar process, if present, or from the nasal cavity (see § 49).

Warm poultices, which were formerly thought so much of, should be entirely discarded. It is better to make an incision at once, even before suppuration has begun.

If there is a fistula, rapid healing generally follows the removal of the diseased tooth. If extraction, however, is not sufficient, the fistulous tract should be opened up and scraped out with a small sharp spoon. In case an external fistula has become retracted to any great extent and causes a disfigurement, it should be removed by two elliptical incisions and the wound sutured with fine silk. If a fistula per-

sists in spite of the removal of the tooth, there is probably necrosis of the alveolar process. In such cases the spontaneous separation of the sequestrum may be awaited, antiseptic mouth washes being used meanwhile, or the healing process may be hastened by removal of the necrotic piece of bone by means of the chisel. Exceptional cases have been observed, in which such extensive necrosis has resulted from an alveolar abscess that all the teeth of one side of the jaw were lost.

Causes of Toothache.—So far as the diseases of the teeth which have been described are concerned, the causes of toothache, which is so prevalent, are, especially, caries, with exposure of the pulp, pulpitis, periostitis, and the presence of tumours within the pulp cavity, particularly internal odontomes. The exposure of the dentine by loss of the enamel occasions, as we have seen, only temporary pain, resulting from differences of temperature, the influence of certain articles of food, etc. The application of an aqueous solution of silver nitrate (1 in 10) is very serviceable for these cases. For toothache caused by caries and pulpitis, Popow recommends a one-twentieth-per-cent solution of permanganate of potash. We have, however, already discussed the treatment of toothache arising from the various causes that have been mentioned.

Rheumatic toothache, so called, without apparent pathological changes in the teeth, is not so common as many suppose. There is, no doubt, such a thing as neuralgia of the teeth, similar to that of the face, resulting particularly from exostoses on the tip of the root, and from the above-mentioned odontomes of the pulp. It is well known, on the other hand, that neuralgia of the second and third branches of the fifth nerve has often been falsely referred to disease of the teeth, and that, acting under this mistake, one sound tooth after another has been extracted without giving relief.

Tartar.—By tartar is understood a limy deposit, especially in the neighbourhood of the neck of the tooth—that is, near the free edge of the gum. It is formed most abundantly on the teeth near the mouths of the ducts of the salivary glands—i. e., on the upper molars and the lower incisors. People who live luxuriously, taking soft food, are more subject to tartar, whereas the biting of hard food frees the teeth more or less from the deposit. It is also common where there is carelessness about cleansing the teeth.

Chemically, tartar is composed of calcium phosphate and carbonate, together with numerous bacteria and mould fungi. Its colour and consistence vary, being usually white or yellowish, though brown or black tartar is found, particularly among smokers.

Tartar is injurious to the gums and to the teeth, and should therefore be carefully removed. It gradually crowds the gum back, and, being a foreign body, irritates it more and more, until inflammatory swelling and bleeding result. It also exercises an injurious influence upon the alveolus. The latter begins to waste, and gradually disappears until the teeth that are involved loosen and finally fall out if the tartar is not removed in time. In old people the quantity is often so great that the teeth, particularly the lower incisors and the upper molars, are, as it were, cemented together by it.

For removing tartar, scraping or chiselling instruments are used, the mirror being also employed so as to insure thorough cleaning of the posterior surfaces (Fig. 201). The proper precautions against the formation of tartar are careful cleansing and frequent examination of the teeth.

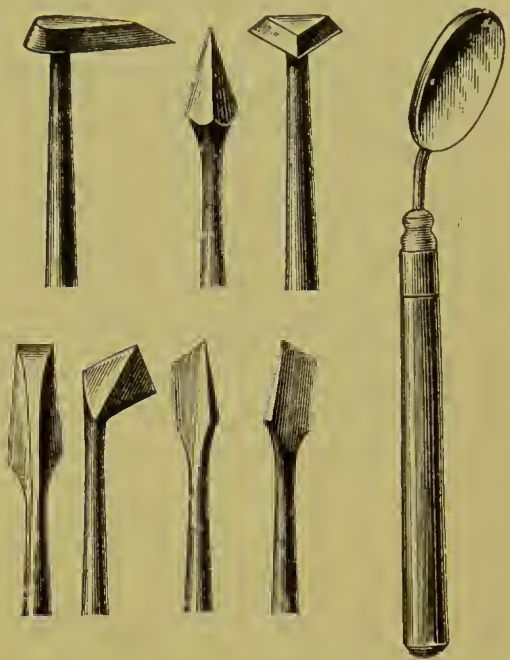


Fig. 201.—Instruments for the removal of tartar and a dental mirror.

As a result of various deposits, and above all of fungi, green and brown discolorations are found, particularly on the incisors and canines. The green coating is caused principally by the presence of mould fungi. These deposits, which are most common in people who are uncleanly or in poor health, adhere closely and can not be removed by the brush. The discolorations are found mostly on the enamel and the dentine, and are, as we have seen, very common in connection with caries.

Microbes may also pass from the pulp cavity into the dental tubuli, as the result of mycotic disease of the former, and occasion bluish-gray or dark-gray discolorations of the teeth. The latter discoloration often occurs in connection with suppuration of the pulp cavity. The teeth are also discoloured in consequence of changes in the colouring matter of the blood within the dental tubuli.

In case of discolorations of this sort, particularly when caused by fungi upon the enamel and dentine, a dentist should be consulted at any early period, in order that the material may be removed by suitable instruments. In this way caries may often be averted and the tooth preserved.

Fractures of the Teeth.—Fractures of the teeth are most frequently caused by a kick, blow, or fall, or during extraction. Transverse, oblique, and longitudinal fractures are distinguished according to the direction of the line of fracture. When the separation is not complete and the pulp and periosteum are not too much crushed and torn, union may take place by the formation of a callus. When a small piece of the tooth is broken off, without exposing the pulp, the surface of the fracture should be filed smooth. If the pulp is exposed in consequence of the fracture, and there is no possibility of the latter uniting, the pulp should be capped, or, if inflamed, destroyed by caustics and filled. The failing piece of the tooth can be artificially replaced later.

Dislocation of the Teeth.—By dislocation of a tooth is meant its complete or partial separation from the alveolus as the result of an injury—e. g., a kick or fall. Dislocation may be accompanied by frac-

ture of the tooth or the alveolus. Fractures of the alveolus often occur during extraction, particularly when there is a bony union between it and the tooth. If the dislocation is incomplete, the tooth still remains in part within the alveolus, and may, if brought back into its normal position, become perfectly firm again. Even where the dislocation is complete, the tooth may heal in place again within the alveolus if the latter is sufficiently deep.

When reposition of a tooth (Mitscherlich, Fredel, Weil, Ferrier) is attempted, it is better to remove a part of the point of the root, as the tooth can not be replaced exactly in its former position. The operation must be done under strict antiseptic precautions, as the replaced tooth can only become firm again when suppuration has been avoided. If the tooth does not show a tendency to become firm and changes its position easily, it may be firmly bound to the neighbouring teeth for the time being, or held in place by a gutta-percha splint. Teeth from a cadaver or from a healthy living person have also been successfully inserted in place of diseased teeth in case the alveolus was well preserved (David, Guérard, Mitscherlich). The reposition of diseased teeth after extraction has been recently recommended again and successfully accomplished by Coleman, Magitot, Rédard, Hoffa, and others. They also emphasize the importance of the most thorough disinfection of the extracted tooth and of the alveolus. Any depressions caused by the removal of carions places may be filled with moist cement. Reposition of the teeth is of the greatest theoretical as well as practical importance. The union of the replaced tooth with its socket is brought about mainly by the periosteum. There may be a primary union, from direct apposition of the alveolar periosteum, with the cement of the tooth. Sometimes absorption of the substance of the tooth precedes its union within the socket, and this may lead subsequently to expulsion of the tooth, which has been thus reduced in size. The pulp in every replaced tooth becomes necrotic. The pulp cavity of the tooth that has reunited is sometimes filled with vascular tissue or bone, owing to a growth of periosteal or medullary tissue from the point of the root or from the sides of the tooth after the pulp cavity has been opened by processes of absorption. Replaced teeth generally become perfectly firm in from three to four weeks.

Tumours of the Teeth.—The tumours which have their origin in the teeth and consist of dental tissue are called odontomes. They are formed particularly during the development of the tooth, as the result of proliferation of odontoblasts from the pulp or from degenerated tooth-germs. Odontomes form outgrowths on the crown or the root, or in the pulp cavity (so-called internal odontomes). Genuine odontomes are rare, and are confined, accord-

ing to Heath, almost exclusively to the lower jaw. Lloyd observed an odontome in the upper jaw. Metnitz has given a detailed description of five cases. He considers deficiency of room, abnormal position of neighbouring teeth, inflammatory processes, and particularly chronic periostitis. of special etiological importance. Two forms of odontome can be distinguished, the soft and the hard—or those with dentine and those without. The exostoses that appear on the teeth are of course not regarded as odontomes, but as osteomes. They arise from proliferation of osteoblasts.

In later life neoplasms, usually of small size, sometimes occur, consisting of enamel, dentine, or cement, or mixed tumours may be developed from a combination of these substances. Emailoids, dentinoids, osteoids, email-dentinoids, and dentine-osteoids have been accordingly distinguished (Schlenker). Emailoids, dentinoids, and email-dentinoids develop from odontoblasts; both the others from osteoblasts. The clinical significance of all these new formations is, for the surgeon, very small, and it need only be mentioned that particularly the odontomes within the pulp cavity and those that have their origin in the periosteum of the roots and the alveoli may give rise to severe neuralgia of the teeth.

Finally, there arise, in rare cases, during the development of the teeth, fibromata, myxomata, and sarcomata, either within the tissue of the pulp cavity or within the periosteum of the roots and the alveolar process, or the medulla of the latter and the gums. All these tumours of the alveolar process and the gum are included under the name epulis, derived from *ἐπὶ τὸ οὖλον*, on the gum. For a description of epulis and other tumours of the jaws, especially the dentigerous cysts, see § 50 (Tumours of the Jaws).

Cleansing the Teeth.—Careful cleansing of the teeth is of the greatest importance for their preservation. Brushes should be selected with reference to the quality or hardness of the teeth. The hardness of the teeth varies greatly with the individual. The first teeth, particularly, should be cleaned with soft brushes. The teeth should, as a rule, not be brushed in a horizontal direction, but from above downward or the reverse, in order that the spaces between the teeth may be better cleansed. They should be cleaned in the morning, and at night before going to bed. Frequent cleansing of the mouth with a disinfecting wash is especially important. Water may be used for cleansing the teeth, or antiseptic solutions, or a good tooth paste or powder. Powders should be as fine as possible. Soaps are the most effective cleansing material. Acids and alkalies are to be avoided, or used in a very dilute form, as the enamel is easily injured by them. The gums, enamel, and dentine are also easily injured by a too energetic use of the brush.

Diseases of the Gums.—Repeated reference has already been made to diseases of the gums, especially in connection with alveolar abscess and tartar formation (gingivitis). Of other inflammations of the gum, I will mention mercurial gingivitis, due to the excessive use of mercury, the characteristics of which are swelling, bleeding, fœtid breath, and the formation of ulcers, and also the gingivitis found in chronic lead-poisoning and scurvy. Lead-poisoning causes the well-known pale-green discolorations of the gum, and scurvy, particularly bleed-

ing. Finally, mention should be made of gingivitis caused by the decay of particles of food, owing to defective cleansing of the mouth and teeth, accompanied by an offensive breath and the formation of small ulcers about the teeth (*gingivitis circularis ulcerosa*, Roser), etc. For diseases of the gums originating in the mucous membrane—e. g., thrush and noma—I refer to their respective paragraphs. Tubercular ulcers of the gum with tubercles in the vicinity sometimes occur in persons with phthisis (Mikulicz). Lupoid affections in otherwise healthy individuals are said to be more common (Hajek).

The first step in treating these forms of gingivitis is to attack the cause. In case of chronic lead and mercurial poisoning the injurious influence must be removed at once ; and in case of a deposit of tartar the same course is to be taken. As for the rest, careful attention should be paid, above all, to cleansing the teeth with disinfecting powders, washes, etc. (see also § 56, Treatment of Ulcers of the Mouth).

Recession of the Gum.—Not alone in consequence of tartar, but without this, the gums of many persons recede at a comparatively early age. This is properly a senile manifestation resulting from the atrophy and absorption of the alveolar process. It leads to increasing exposure of the necks of the teeth and to loosening of the latter. Too energetic a use of stiff brushes favours this retraction, even in persons who are comparatively young. König recommends painting the parts with a ten-per-cent solution of chloride of zinc.

Baudet reported a case in which, after an injury to the head (probably fracture of the base of the skull with concussion of the brain), progressive absorption of the alveolar process of the upper jaw ensued, and loss of all the teeth upon the latter (see also page 398).

For tumours of the gum, see § 50.

Extraction of Teeth.—Teeth are now extracted exclusively by the use of special forceps. For deeply seated roots, which can not be reached by forceps, the so-called socket chisel and other prying instruments are used, such as elevators, Lecluse's lever, etc. (see Fig. 206). The tooth key which was formerly used is obsolete and has been properly abandoned since the tooth was, as it were, broken out, in too rough and violent a manner.

Every extraction should be undertaken in accordance with antiseptic rules. All the instruments used should, accordingly, be carefully sterilized, etc.

The indications for extracting teeth vary somewhat, according to the dentition. The following rules apply to the extraction of milk teeth: It is a general principle that the first teeth should not be drawn without urgent reason, lest the development of the permanent

teeth be interfered with by diminution in the size of the jaw in consequence of lessened growth, or of premature closure of the alveoli. Extraction is necessary, however, in case of inflammation and suppuration of the pulp cavity, periostitis, alveolar abscess, necrosis, and fistulæ, or, finally, in case of the irregular eruption of a permanent tooth. It may also, as a rare exception, be necessary to extract teeth that exist at birth if nursing the child is thus made painful for the mother. Such teeth are without roots and are easily drawn.

The following are, in general, the indications for extracting second teeth: 1. Suppurative inflammation of the pulp cavity, especially when extension to the periosteum is threatened. 2. Suppurative periostitis and alveolar abscess. 3. Fistulæ. 4. Necrosis of the root, necrosis of the jaw, and empyema of the antrum following alveolar abscess. 5. Neuralgia of the teeth occasioned by tumours in the pulp cavity or on the roots (odontome, exostosis, sarcoma).

Sound teeth are rarely extracted. The grounds for drawing them are chiefly abnormal position of the teeth and the necessity, when the jaw is too small, of making room for other teeth that are in their normal position. Surgical operations sometimes require the removal of sound teeth, or it may be necessary in order to facilitate the nourishment of patients suffering from trismus, when the introduction of a stomach tube through the nose is impracticable.

Leukæmia and hæmophilia contraindicate extraction, as fatal hæmorrhage may ensue.

The Technique of extracting Teeth consists, 1, in applying the forceps adapted to the particular tooth; 2, in pushing its jaws up under the gum and closing the forceps when properly placed; 3, in loosening the tooth from its socket; 4, in its extraction.

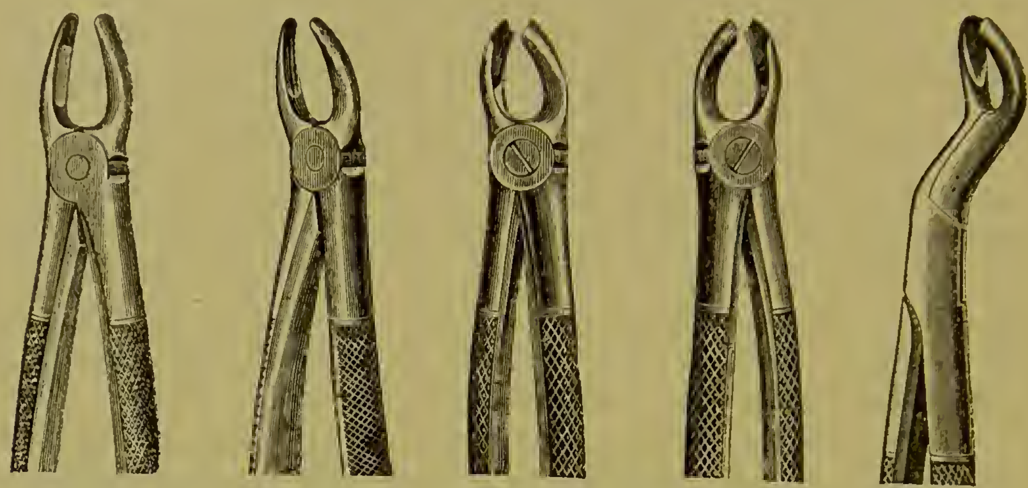
The shape of the forceps varies with the kind of tooth and its location, as is more exactly shown in Figs. 202 and 203.

Aside from forceps used in the extraction of roots, the following seven forms are essential (Figs. 202 and 203): One, respectively, for the upper and lower incisors and canines, the upper bicuspids, the lower bicuspids, the upper molars on the right side, the upper molars on the left side, and the lower molars. Two additional forceps for the upper and lower wisdom teeth are also useful.

The patient sits in a firm chair, and the operator stands, as a rule, at his right side. An assistant, placing his hand about the temples of the patient, holds his head to one side and bends it a little backward, or the chair may be so constructed that the head may rest in this position. If the operator is without an assistant, he places his left arm around the back of the patient's head, draws the lips or the

corner of the mouth to one side, and introduces the forceps with his right hand.

The operation of extraction is so slight and so quickly over that an anæsthetic is generally unnecessary. It is used only at the special



For the upper incisors and canines. | For the upper bicuspids. | For the upper molars on the right side. | For the upper molars on the left side. | For the upper wisdom teeth.

FIG. 202.—Dental forceps for the upper teeth.

request of the patient or in case of extractions which promise to be unusually painful. It should always be given with caution and never without the presence of an assistant. In case of so-called mixed

For the lower incisors and canines. | For the lower bicuspids. | For the lower molars on both sides. | For the lower wisdom teeth.

FIG. 203.—Dental forceps for the lower teeth.

narcosis—e. g., the use of chloroform after a hypodermic injection of morphine—it is not necessary to bring the patient completely under the

influence of the drug, but the extraction can be accomplished without pain before the stage of excitement has begun. Patients may, perhaps, utter exclamations of pain, but they have usually felt nothing. The object can also be attained in the same way, as a rule, by the use of chloroform without morphine before the patient comes fully under its influence. If the narcosis is complete, great care must be taken that respiration is not disturbed during the extraction, and that blood is not aspirated into the lungs. Ether and laughing gas are also commonly used instead of chloroform, and recently ethyl bromide has been employed with great success. Ether and laughing gas are admirably adapted to the purpose, and are much to be preferred to chloroform. Fatal results are also much less common from their use than from that of chloroform. Scheff quotes an instructive statistical calculation by Andrews bearing upon this point, according to which, among 75,000 cases in which laughing gas was used, not one resulted fatally, and but one death occurred in 23,200 cases in which ether was used. Death ensued in one case out of 5,588 from the use of a mixture of chloroform and ether, and of 2,723 cases in which chloroform alone was used, one resulted fatally. Pental, a new anæsthetic, is not to be recommended.

Local anæsthesia with ether spray or cocaine and other substances is not advisable, inasmuch as it is not sufficiently effective.

When, in accordance with Figs. 202 and 203, the proper instrument has been selected and its jaws have been pushed as far beneath the gum as possible, the tooth is then turned outward as a rule, dislocated, and extracted. The last lower molar is turned inward, the reason being that it lies behind the ramus of the jaw. Also when the crown inclines strongly inward, the tooth is first turned inward somewhat and then outward and drawn. Fracture of the tooth—that is, the breaking off of the crown—is best avoided by pushing the jaws of the forceps as far as possible under the gum, and not pressing them together too hard when grasping the tooth. The extraction of wisdom teeth may be attended with particular difficulty, and it is therefore well to have special forceps, such as those represented in Figs. 202 and 203. If the crown has been extensively destroyed, as the result of caries, so that the tooth in question stands below the level of the others, the extraction will be the same as that of roots (see page 328).

It is often necessary to grasp the wall of the alveolus together with the tooth and bite out from it a corresponding piece of bone. This piece of the alveolus is then extracted with the tooth. It is well sometimes, before extraction, to free the gum around the tooth with a pointed knife.

As has been said, the tooth key (see Fig. 204), which was formerly much used, has been properly abandoned. The treatment was too rough and always attended by crushing of the wall of the alveolus, since the tooth was pried out by turning the instrument. The so-called ward of the tooth key, wrapped around with gauze, was laid sidewise on the alveolus; the point of the small bent hook seized the border of the tooth and was held in place with the finger.

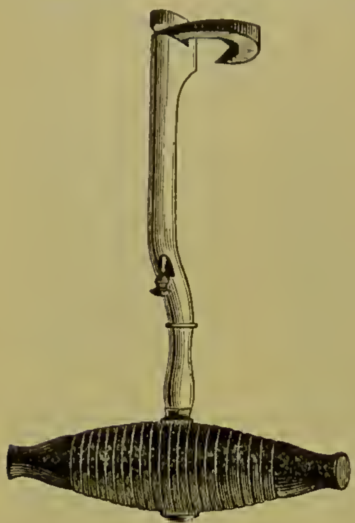


Fig. 204.—A tooth key.

The extraction of roots after the crown has been destroyed in consequence of caries is often very easy and attended by little pain in case they can be grasped by forceps adapted to this special purpose (see Fig. 205), and have been loosened by absorption of the alveolus and recession of the gum.

The extraction of deeply seated roots, which can not be grasped with forceps, is more difficult. Use may then be made of the old socket chisel (Fig. 206) and other tooth levers (Fig. 206), or of a small bone-chisel.

The socket chisel and the English lever are pushed between the root and the alveolus, and the former is then pried out by lowering the

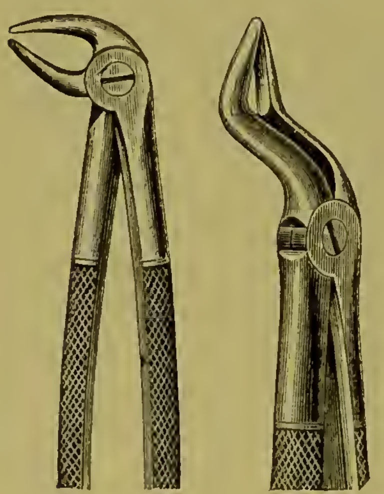


Fig. 205.—Forceps for the extraction of roots: *a*, for the lower; *b*, for the upper jaw.

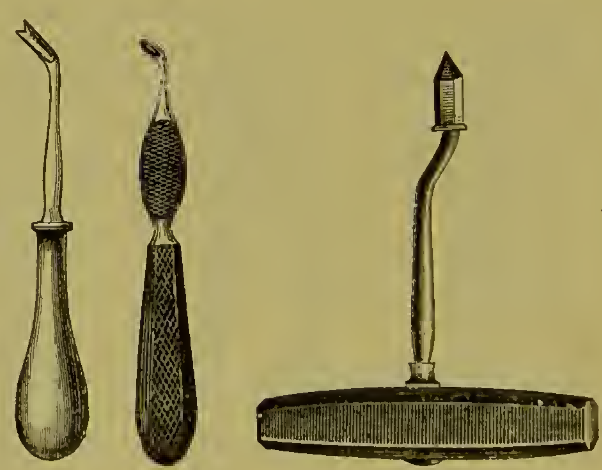


Fig. 206.—Tooth levers or elevators: *a*, socket chisel; *b*, English tooth lever; *c*, Lecluse's tooth elevator.

handle of the instrument. The less serviceable lever devised by Lecluse is pushed between the root and the neighbouring tooth, so

that the flat surface of the end of the lever lies against the root and the curved surface against the next tooth. The flat surface is then brought upward by turning the instrument, and the root is thus pried out. A root may also be drawn out, as a cork is drawn from a bottle with a corkscrew, by carefully embedding a screw in its canal. Of the instruments that have been named, the English lever can be most strongly recommended.

If the roots are very deep, whether there be bony union with the alveolus or not, it is often a good plan, after freeing the gum, to cut through the alveolus with Roser's bone-cutting forceps and then extract the root together with the separated piece of the alveolus. The alveolus and the root may also be simultaneously removed by the use of rongeur forceps; or the alveolus may be opened with a chisel and the root thus extracted. The last-described methods are especially resorted to when deeply seated roots have a bony union with neighbouring teeth, and also in cases of exostoses of the roots, odontomes, divergence of the roots, etc.

Accidents attending the extraction of teeth are exceptional. Fracture of the tooth to be drawn, fracture and dislocation of neighbouring teeth, fracture of the alveolar process, laceration and inflammation of the gum leading to abscess and gangrene of the same, are easily prevented. The hæmorrhage is generally slight and is soon arrested by washing out the mouth with cold water. Sometimes, however, the bleeding is more profuse, especially, for example, after the extraction of one of the lower molars, which reaches so far downward that the artery that supplies it is torn away close to the inferior dental artery. Bleeding in cases of leukæmia and hæmophilia is the most dangerous. A "bleeder" may die from the loss of blood due to the extraction of a tooth if the bleeding be not immediately arrested. In such cases extraction must be avoided, or, at all events, undertaken with extreme caution, the bleeding thoroughly arrested, and the patient carefully watched for fear of possible renewal of the hæmorrhage. If cold water does not stop the bleeding, the alveolus should be firmly packed with iodoform gauze, powdered antipyrine, or with cotton dipped in the chloride of iron. If the bleeding is very severe, as in the case of bleeders, for example, a tampon of cotton and bichloride gauze or iodoform gauze should be added and the patient instructed to bite firmly into this pad. It is also a good plan to place a cork with a wedge-shaped piece cut out between the teeth, and in this way compress the alveolus from three sides. The jaws are bound as firmly as possible together by means of a three-cornered piece of cloth or several thicknesses of bandage. In dangerous cases the best method is continued digital compression with firm gauze pads or absorbent cotton soaked in the chloride of iron. In a case of hæmophilia I saw the application of the cautery attended with no good result, whereas the object was accomplished by packing the alveolus with absorbent cotton soaked in the chloride of iron and by digital compression with aseptic gauze pads, so that the extremely anæmic and almost moribund patient fully recovered.

After the extraction of a tooth the mouth should always be carefully cleansed with an antiseptic solution, and, in case of suppuration, iodoform gauze, etc., may be laid in the opening to prevent septic inflammation and necrosis of the bone (see also § 48). In rare cases death has ensued from septic infection following the extraction of a tooth, especially after laceration and gangrene of the gum.

As regards the replacement of extracted teeth, see page 322. This should be done at once, in case a sound tooth is drawn by mistake.

§ 48. **Inflammatory Processes of the Jaws.**—Among inflammatory processes of the upper and lower jaws we have already, while treating of diseases of the teeth, become familiar with suppurative periostitis resulting in necrosis of the alveolar border. This suppurative periostitis of the alveolar process, following decay of a tooth, and inflammation and suppuration of the pulp spreading to the periosteum of the roots, is generally circumscribed, in the form of an alveolar abscess, and the ensuing necrosis is correspondingly limited. Sometimes, however, as we have seen, a more diffuse septic inflammation follows suppuration starting from the teeth, so that a more extensive necrosis of the jaw may ensue. We have cited such cases of widely extended septic inflammation, particularly on the lower jaw, which may result in death from general sepsis. When such cases of longer-continued suppuration occur, particularly if on the lower jaw, large pieces, involving the whole thickness of the bone, may become necrotic.

The necrosis resulting from traumatic suppurative periostitis or syphilitic and tubercular periostitis is, as a rule, circumscribed. Syphilis attacks the jaws most commonly by way of the nose and mouth, in the form of a gummatous periostitis and osteomyelitis (syphilitic caries) of the nasal and palate processes of the superior maxillary bone, and here produces defects. Extensive destruction also occasionally takes place in the lower jaw, as the result of syphilitic periostitis and osteomyelitis. The favourite seat of tubercular periostitis and osteomyelitis (tubercular caries) is the anterior border of the orbital surface of the superior maxillary bone, where characteristic, retracted fistulæ of the skin of long standing so frequently occur. The sequestra formed in this region are generally small, but the process may extend farther into the orbit and lead to fatal tubercular meningitis.

Besides tubercular and syphilitic inflammation of the soft parts and bones, noma and mercurial stomatitis also lead to inflammatory necrosis of the jaws.

Actinomycosis (see Principles of Surgery, § 86) of the jaw is rare. I saw one case, that of a peasant girl, where the disease was commu-

nicated from a cow, and originated in decayed teeth. Here the actinomycosis ran its course in part under the form of a spreading suppurative inflammation, and in part attended by the formation of nodules with swelling of the lower jaw. As regards diagnosis, the characteristic granules in the pus and granulation tissue, as well as the detection under the microscope of the actinomyces (ray fungus), are decisive.

The acute suppurative periostitis and osteomyelitis of the jaws in children, occurring particularly during the time of dentition, after measles, scarlet fever, small-pox, and other severe infectious diseases (Salter), are of special interest. They also occur independently of the constitutional diseases just mentioned. At all events, we have here to do with infection by microbes and their ptomaines which results from a foul condition of the secretions of the mouth due to defective care of the same. The progressive swelling and suppuration, especially of the alveolar processes, are attended with severe constitutional manifestations. The teeth become loose and fall out, and pus often exudes in great quantities from the alveoli. Extensive necrosis may ensue with loss of the tooth germs in this region. Marked necrosis seldom occurs in the upper jaw, but is more common in the lower jaw, where the ramus, with its condyloid process, or both halves of the jaw even, have sometimes been involved. The course of the disease in such cases is very protracted, the sequestra become loosened in the course of a few months, and inflammatory exacerbations frequently occur during this process of separation.

In treating all inflammatory processes of the jaws, especially suppurative periostitis and osteomyelitis and necrosis, attention should be directed, first of all, to the cause. In cases of acute infectious periostitis and osteomyelitis, free incisions are made in the gum down to the bone. If there is a diseased tooth it must be extracted at once. Any tendency of the suppuration to spread downward toward the neck, or to involve the entire upper jaw, with the antrum and spheno-maxillary fossa, should be carefully combated. In cases of syphilitic and tubercular caries, not only local treatment, such as the use of the sharp spoon, etc., but also a corresponding constitutional treatment is of importance. This will consist, in case of tuberculosis, in prescribing a strengthening diet and mode of life, and in syphilis in the use of mercury and the iodide of potassium (see Principles of Surgery, §§ 83, 84). In case of traumatisms affecting the jaws and in infectious diseases the most scrupulous cleansing of the mouth should always be insisted on as a prophylactic measure. Where necrosis exists, the separation of the sequestrum should usually be waited for, but profuse suppuration may

make it necessary to remove it earlier subperiosteally by the use of the chisel. Sequestra are, if possible, removed through the mouth and nose. Teeth that are loosened may become firm again if the periosteum of the necrotic alveolus is preserved. In the case of actinomycosis of the lower jaw that was mentioned above there was extensive necrosis of the entire right half of the jaw, with the exception of the condyloid process. The teeth in this region were all loosened, but afterward became perfectly firm, and the restitution of the jaw was so complete that there was no subsequent disfigurement whatever. Large sequestra of this sort are also removed if possible through the mouth.

Phosphorus Necrosis.—Phosphorus necrosis of the jaw is due to the injurious influence of the fumes attending the manufacture of phosphorus matches. Since the latter have been more or less superseded by the so-called safety matches, and since the authorities have insisted upon the observance of strict hygienic regulations in manufactories where phosphorus is used, phosphorus necrosis has become much less common. It is most prevalent, perhaps, in the Thuringian forest, where the manufacture of phosphorus matches is now carried on chiefly in the homes, and prophylactic rules are not sufficiently observed.

For our knowledge of the causes of phosphorus necrosis we are mainly indebted to Wegner, who has studied, by experiments on rabbits, the influence of phosphorus or phosphoric fumes upon the periosteum and bone. The disease is confined almost exclusively to workmen with carious teeth. In consequence of the direct action of the inhaled fumes upon the periosteum of the jaw, there occurs at first a circumscribed ossifying periostitis of the alveolar process—that is, new bone is formed with a corresponding enlargement of the jaw. Arsenic and pyrogallic acid have, according to Maas, Gies, Binz, and H. Schultz, the same osteoplastic action as phosphorus. The new bone due to the inhalation of phosphorus generally forms first in the neighbourhood of decayed teeth, since the latter allow the fumes to reach the periosteum of the alveoli. Owing to the presence of the microbes of inflammation and putrefaction within the mouth, suppuration ensues, sometimes between the periosteum and new bone, sometimes between the latter and the old bone; and, as the result of this, necrosis follows, varying in extent, affecting the old bone at first, and, if the trouble continues, the newly formed bone as well. The distinct stage of ossifying periostitis is sometimes absent, and from the outset suppurative periostitis and osteomyelitis, with progressive necrosis, are predominant. The lower jaw is more frequently attacked than the upper, and in severe cases the entire lower jaw may be destroyed, and even the sphenoid

bone and the basilar process of the occipital bone may be involved. In such neglected caess death may ensue from meningitis, aspiration—pneumonia, or general marasmus.

The treatment of phosphorus necrosis is, first of all, prophylactic. Where phosphorus is used in manufacturing, only persons with sound teeth should be employed, and suitable hygienic rules must be strictly enforced for the protection of workmen. Good ventilation and careful cleansing of the mouth are especially necessary. At the first indication of disease in the form of swelling of the jaws or caries of the teeth, those affected should be removed from the injurious influence of the fumes. Keeping in the fresh air, good nourishment, and frequent cleansing of the mouth with antiseptic solutions are to be recommended. If suppuration or necrosis is already present, it becomes a question whether the separation of the sequestrum and the formation of an involucrum to take the place of the dead bone shall be waited for or not. In mild cases, where there is little suppuration, it is well to wait for a time, using the precautionary measures that have been mentioned. On the other hand, an operation should be performed promptly and the as yet unloosened sequestrum removed in all those cases in which the patient suffers from profuse suppuration and the separation of the dead bone progresses too slowly, or when the newly formed bone likewise, as the result of suppuration, shows signs of necrosis. Removal of the sequestrum—sequestrotomy—is accomplished, if possible, from within the mouth. The periosteum and newly formed healthy bone are carefully spared by being lifted to one side by an elevator while the sequestrum is extracted. In case of early operation, if the dead bone is not yet separated it is cut through subperiosteally with hammer and chisel, or with a metacarpal or chain saw, at its junction with the sound bone. In advanced cases the subperiosteal removal of the entire necrotic jaw is sometimes necessary (see the technique of this operation, § 54, page 358).

§ 49. **Diseases of the Antrum of Highmore.**—Of the diseases of the antrum or maxillary sinus, we mention first dropsy—i. e., a collection of mucus or serum which may result from a natural or, more frequently, an acquired closure of the opening communicating with the nasal cavity. Many surgeons erroneously doubt the existence of this dropsy of the antrum. I saw a very characteristic case in which the disease was probably congenital and of such extent that the palate process and the anterior wall of the superior maxillary bone had a perforation the size of a cherry, and the roots of the otherwise perfectly sound teeth projected freely into the antrum, which was decidedly dilated below. An opening into the nasal cavity could not be found.

One was artificially made through the defect in the front wall of the jaw by means of a trocar and chisel, and the patient completely recovered. Such cases of genuine dropsy resulting from a congenital absence of communication with the nasal cavity are rare.

In a large majority of cases of dropsy we have to do with a pseudo-dropsy—that is, with tumours of the antrum which have undergone cystic degeneration, especially hypertrophies of the mucous membrane, so-called mucous polyps, and sometimes also cysts of the jaw, which, originating from tooth follicles, have grown into the antrum. Subperiosteal cysts of the anterior wall of the superior maxillary bone may also be mistaken for dropsy of the antrum. These subperiosteal cysts originate partly in tooth germs, and, as is properly emphasized by Genzmer, they arise in part from subperiosteal alveolar abscesses. In the latter case the abscess has not broken through the mucous membrane, but has become encapsulated and gradually taken on more and more of the nature of a cyst. Since the front wall of the cyst consists of the raised-up periosteum, it finally ossifies. The anterior wall of the antrum wastes in consequence of the pressure of the cyst; it is gradually pushed in the direction of the orbit, or it becomes eroded, and the cyst then breaks through into the antrum. Such a subperiosteal cyst, situated on the anterior wall of the upper jaw, its front wall likewise consisting of bone, may be mistaken for genuine dropsy of the antrum, whether the cyst after erosion of the anterior wall of the jaw be in direct communication with the maxillary sinus, or the anterior wall of the latter be more and more sunken in consequence of pressure of the cyst.

The symptoms of genuine dropsy and pseudo-dropsy resulting from mucous polyps or cysts consist, above all, in a bulging of the body of the jaw which may be recognised from in front and from within the mouth, above the alveolar process at the reflection of the mucous membrane, and often also on the hard palate. The wall of bone may become so thin as to crackle like parchment when pressed upon, or may, as in the case mentioned above, be entirely broken through anteriorly and toward the hard palate. Likewise, in the case of subperiosteal cysts of the anterior wall of the jaw, which at first are not situated in the antrum, the raised-up ossifying periosteum emits, when pressed upon, a characteristic crackling sound. Upon opening the antrum or the subperiosteal cyst, a varying condition of things is found, according to the nature of the case. Usually pseudo-dropsy of the antrum is found, caused by mucous polyps or dentigerous cysts of the jaw, with displacement of the opening into the nasal cavity. In rare cases genuine dropsy exists, with absence or obstruction of this same opening.

In the third class of cases we have to do with subperiosteal cysts of the anterior wall of the jaw, which do not lie at all in the antrum, or have only secondarily broken through into it as the result of erosion from pressure on its anterior wall. If these periosteal cysts start from an alveolar abscess, their connection with a diseased tooth can generally still be made out. If this causal connection fails, it may be a case of subperiosteal dentigerous cyst.

For the treatment of dropsy of the antrum, see page 337.

Empyema of the Antrum—i. e., a collection of pus within the antrum —arises most commonly from the extension of suppurative processes within the nasal cavity and from disease of the teeth ; e. g., suppurative periostitis of the root with discharge into the antrum. It also occurs after injuries, particularly compound fractures, and from the entrance of foreign bodies, such as bullets, broken points of knives, etc. Moreover, an alveolar abscess that has extended upward may closely resemble empyema of the antrum.

The symptoms of empyema of the antrum consist usually in a discharge of pus from a fistula in the alveolar process or from the nose, especially when the patient lies on the sound side. In case of longer duration of the empyema and a more abundant collection of pus resulting from closure of the outlet into the nasal cavity from swelling of the mucous membrane, the affected side of the face enlarges and the antrum gradually becomes distended. A pyæmic condition may ensue from the retention of pus—i. e., fever with intermittent chills, and a corresponding disturbance of the general health. Necrosis of one of the walls of the antrum is especially likely to follow retention of pus, the bone becoming perforated, so that the suppuration may spread farther and involve the other cavities of the face. In severe cases death may follow from pyæmia or meningitis.

The treatment of empyema of the antrum depends, above all, upon the cause. In doubtful cases the presence of pus may be determined by irrigation of the antrum through the nose, or trial puncture with a trocar or pointed galvano-caustic burner inserted through the lower meatus or between the second bicuspid and first molar. Carious teeth and sequestra of the alveolar process should, when present, be removed. In such cases there are usually fistulæ, and through these, or after removal of the diseased root or sequestrum, the floor of the antrum may be opened with a small Volkmann spoon. The pus has in this way a good outlet, and drainage or irrigation of the cavity is usually unnecessary. Special care must be taken that no particles of food enter the antrum. Recovery often takes place promptly. If a fistula remains, owing to a defect in the floor of the antrum, the same may be

closed by an operation, or artificial teeth may be prepared by a dentist with the plate so arranged as to cover it. In case of an operation, the edges of the defect are freshened; the periosteum and mucous membrane, are raised in the form of one or two flaps, laid over the defect, and united by suture.

If the teeth are sound, and extraction therefore undesirable, the lower anterior wall of the antrum may be opened with a chisel or large trocar from within the mouth after dividing the reflection of the mucous membrane and elevating the periosteum. If it seems desirable to insert a drainage-tube for a few days, it is fastened by a suture, or a small cross-drainage-tube may be passed through the end that lies in the antrum.

Ziem opens the antrum between the bicuspids, or between the second bicuspid and the first molar, by means of the boring machine used by dentists.

Mikulicz advises opening the antrum from the inferior meatus at the level of the inferior turbinated bone, thus making a permanent communication between the antrum and the nose. For breaking through the comparatively thin wall of bone, a curved, daggerlike instrument provided with a safety guard (see Fig. 207) is used. This is passed through the inferior meatus, around the inferior turbinated bone; the point is then turned outward and the wall pierced. In order to secure a sufficiently large opening, the edges of the puncture are cut away somewhat. This perforation of the antrum through the nasal cavity is strongly to be recommended in case an opening through the carious or necrotic alveoli is not indicated by the presence of fistulous tracts in the alveolar process. The method is an easy one, being impossible only when the nasal cavity is abnormally narrow or when the inferior turbinated bone is much thickened.

Fig. 207.—Mikulicz's trocar for opening the antrum.

Drainage or irrigation of the antrum is accomplished, either through the fistula made within the mouth or through the nose, by means of a silver ear-catheter or Hartmann's tube. I am not in favour of irrigations. They are unnecessary when the cavity is opened from within the mouth. They are, moreover, directly injurious, as pus is washed into the neighbouring cavities of the nose or head. Catheterization of the antrum from within the nose is often impossible in case of empyema.

Cases of empyema of the accessory cavities of the nose which were said to have been treated for months have been cured in a few days

by exciting an acute inflammation (injection of a twenty-per-cent solution of aluminium aceticum tartaricum) (Schech).

Dropsy of the antrum is treated, in general, in accordance with the same rules. An artificial opening is made here also, either from within the nasal cavity, as recommended by Mikulicz, or from within the mouth through the lower anterior wall of the canine fossa, or, in case of diseased teeth, through the alveoli. In the case that was mentioned of apparently congenital dropsy, with a defect in the front wall of the jaw and in the floor of the antrum, I made the opening from the cheek, and then from within the antrum established a permanent communication with the nasal cavity by means of a trocar, enlarging the opening with hammer and chisel. In case of mucous polyps also, or other new growths in the antrum, it is often necessary to reach the cavity from the cheek, if room enough can not be secured in the canine fossa from within the mouth.

In case of subperiosteal abscesses and cysts situated in the anterior wall of the jaw, also in case of pseudo-empyema and pseudo-dropsy, the opening should always be made from within the mouth. The upper lip is everted, the reflection of the mucous membrane, and the periosteum, are divided, and the bony wall is entered with a chisel, trocar, or knife, according to its thickness. The opening into the cyst must be made about large enough to admit a finger. The cavity is allowed to heal gradually by granulation. It must not close too soon, as a recurrence may ensue.

Illumination of the antrum by means of an electric light (Voltolini) has been repeatedly undertaken recently in treating diseases of this cavity, but its worth as a means of diagnosis must not be too highly estimated.

This illumination, which depends upon the translucency of the normal tissues and the opacity of pus, is secured as follows: The patient and operator being in a dark room, the former is made to insert a small electric lamp into the mouth. Upon his closing the lips the lamp is made to glow, whereupon the rays pass through the palate into the antrum and nasal cavity. If there is pus within the antrum, or, more correctly, if the latter is filled with pus, that side of the face, as well as the pupil, which usually appears red, remain dark. The method is, however, not trustworthy.

§ 50. **Tumours of the Upper and Lower Jaws.**—We touched briefly upon some of the tumours of the upper and lower jaws when speaking of pseudo-dropsy and pseudo-empyema of the antrum.

The most common tumours of the antrum are hypertrophies of the mucous membrane—polyps, or mucous polyps, so called, which resemble nasal polyps (see Nasal Cavity, § 41, page 278). Polyps of the antrum are often not discovered during the life of the patient, and are seldom treated. Sometimes, however, their growth is such as to expand the antrum and perforate its

wall in the direction of the nasal cavity, for example, or of the soft palate, or anteriorly. Mucous polyps sometimes form a large cyst, which may be mistaken for dropsy of the antrum.

Other tumours of the antrum, likewise, rarely attain to such a size as to perforate its walls, and thus become accessible for diagnosis. Enchondroma, myxoma, sarcoma, and carcinoma have been found within the antrum.

The treatment of tumours of the antrum consists in opening the cavity in the manner described in § 49, pages 335 and 336. If but little room is needed, as in the case of mucous polyps, for instance, the opening should be made from within the mouth in the canine fossa. Mucous membrane, periosteum, and bone may be dissected up from within the mouth or through the cheek in the form of a flap, and after the removal of the tumour this flap may be brought back into its normal position. When the tumour is large it may be necessary to resect a portion of the front wall of the antrum from the outside. Entire removal of the superior maxillary bone is indicated in case of malignant tumours of the antrum—e. g., sarcoma or carcinoma.

The other tumours of the upper and lower jaws are more or less analogous, and, for the sake of convenience, we take them up together.

We distinguish first tumours of the alveolar process of the jaws, and secondly tumours of the body of the jaws and its processes.

Tumours of the Alveolar Process.—The name usually given to tumours of the alveolar process is epulis, which means literally "situated on the gum" (ἐπὶ τὸ οὖλον). The forms of epulis are, histologically, very varied; but they are chiefly connective-tissue growths. In this category belongs the granuloma or pedunculated fibroma, a growth most common in children, from the alveoli of extracted teeth, from fistulæ, or from the exposed pulp of a decayed tooth. Tumours originating from the teeth have already been mentioned on page 322. Among other benign tumours of the alveolar process, the enchondroma and the osteoma (exostosis) or more diffuse hyperostoses occasionally occur.

The epulis is most frequently a sarcoma of either the spindle-celled or round-celled variety. The number of cells and the amount of connective tissue are very variable, so that soft and hard forms are observed. Of special frequency is the so-called giant-celled sarcoma (myeloid sarcoma), in which, in addition to spindle and round cells, giant cells are more or less abundant. This form of sarcoma is comparatively non-malignant and its growth is slow. Metastases occur late or not at all, and, after a thorough removal, complete recovery often results without recurrence. Epulis has, in general, a very good prognosis. Of twenty-two hospital cases radically operated on by Czerny, fifteen were permanently cured (Wassermann).

Sarcoma and fibroma of the alveolar process of the jaw begin usually in the periosteum or medulla. They are either pedunculated or sessile. If the fibroma or sarcoma originates in the medulla, the covering of bone is more and more expanded by the growth of the tumour until it disappears altogether. Sometimes, in case they keep on growing, they enter the antrum,

which they may fill, expand, and finally perforate. The soft, malignant sarcoma, with many cells, has sometimes, like the carcinoma, an ulcerated surface.

The carcinoma originates in the epithelium of the mucous membrane of the gum and forms, as a rule, rapidly growing, irregular, sloughing ulcers with indurated borders, which quickly extend to the bone. I recently operated upon two cases of epithelioma in the neighbourhood of the wisdom teeth which had extended to the soft palate and tonsils. In a pronounced case of epithelioma of the gum death usually follows quickly from increasing marasmus, the result of sloughing, defective nourishment, or hæmorrhage.

The treatment of tumours of the alveolar process consists in their speedy removal by operation. In case of a small granuloma or fibroma, growing out from a fistula or from the pulp of a decayed tooth, the extraction of the tooth and removal of the tumour by the cautery or knife are indicated. The tooth involved should also be extracted, as has been said, in case of an odontome or exostosis on the tooth with secondary neuralgia. Exostoses of the alveolar process are removed with a chisel. Larger tumours, which have already partly destroyed the bone, should be removed, together with the portion of the alveolar process that is involved. In all malignant new growths, such as carcinoma and sarcoma, a thorough removal of the growth well within sound tissue must be undertaken, or complete excision of the superior maxillary bone may be indicated (see §§ 53, 54).

Tumours of the Body of the Upper and Lower Jaws are not infrequent. They are chiefly connective-tissue growths. The more or less benign tumours of the jaws are the fibroma, the enchondroma, and the osteoma.

The fibroma originates in the periosteum or medulla, and is most common in young persons. The periosteal fibroma, situated on the bone, is usually a sessile tumour, though sometimes pedunculated, which gradually causes the bone to become absorbed and may attain a considerable size. It sometimes extends, for example, into the antrum and the nasal cavity, fills them more or less completely, and, after breaking through the bone, becomes visible beneath the skin of the cheek.

The fibroma which begins in the medulla has at first a complete covering of bone, which, as the growth of the tumour progresses, may entirely disappear. The bony envelope of the endosteal fibroma is usually not the expanded cortex (this disappears at the place where the fibroma arises), but a new growth of bone arising from inflammatory irritation of the periosteum.

The hard fibroma is much more common than the soft. The fibroma is often combined with tumours of other types, especially with enchondroma, osteoma, myxoma, and sarcoma, so that we have corresponding mixed tumours (fibro-sarcoma, osteo-fibroma, fibro-myxoma, etc.). As is seen in Fig. 208, the osteo-fibroma may attain a great size and so have a malignant course. A malignant recurring fibroma may finally change into a sarcoma.

The enchondroma, which occurs most frequently in young persons, is either a purely cartilaginous tumour, originating in the periosteum or medulla, or

a mixed tumour. Its most frequent combinations are with the fibroma, the myxoma, and the osteoma. It sometimes attains a great size, and not infrequently extends into the antrum.

Osteoma of the upper or lower jaw is, generally speaking, rare. Osteoma of the antrum may originate in the ethmoid bone. In rare cases diffuse enlargements occur in the bones of the face and skull which may be compared to elephantiasis of the soft parts. Virchow has given the name of leontiasis ossea to these multiple growths of bone on the face and skull (see Fig. 209). They are really the result of diffuse inflammation of the periosteum which comes on in attacks with erysipelas-like inflammation of the skin of the face. Colds and syphilis have been looked upon as predisposing causes, but not rightly, in my opinion. I believe that leontiasis ossea is an independent disease which has nothing to do with acromegaly or syphilis. It begins in young persons of both sexes, who are congenitally predisposed to it but otherwise healthy, with painless, usually symmetrical thickenings of the facial and cranial bones. The malar bone is usually the first to be affected. It progresses slowly and causes, finally, marked deformity; the sense of smell and vision are gradually lost, and death ensues in the course of years, perhaps ten to thirty, usually with the symptoms of compression of the brain. As shown in Fig. 209, enormous nodular or more diffuse thickenings of the facial bones, especially of the jaw, may result. No form of treatment has as yet been found of any avail against this progressive formation of bone. Operative measures have been tried in vain. The iodide of potassium is probably the most useful internal remedy.

Fig. 208.—Osteo-fibroma of the inferior maxilla in a woman forty-six years old.

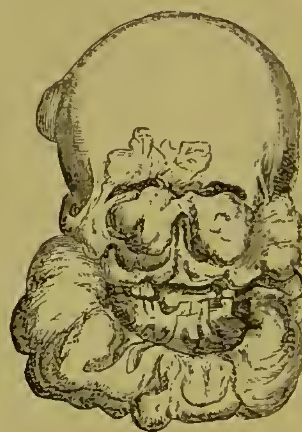


Fig. 209.—Diffuse nodular hypertrophy of the bones of the face (leontiasis ossea, Virchow). This skull, which is of unknown origin, is in the Musée Dupuytren.

The most common tumour of the jaws is the sarcoma, the various forms of which are found either alone or in combination with the enchondroma, the osteoma, the fibroma, the myxoma, or with cysts. The spindle-celled sarcoma, the giant-celled sarcoma, the cystic sarcoma, the alveolar sarcoma, and, above all, the malignant, soft, round-celled sarcoma with its abundant cells, the so-called medullary sarcoma, have all been found. The sarcoma originates usually in the periosteum or the medulla, sometimes also in the pulp of the teeth or in the soft parts covering the jaws, involving, in the latter case, the bone secondarily. The periosteal sarcoma, like the periosteal

fibroma, is attached to the bone, while the medullary sarcoma is surrounded at first by a covering of bone, which it finally breaks through. The medullary sarcoma is an especially malignant tumour. It grows very rapidly, destroying the bone in all directions, so that the patient generally comes to operation too late. I saw an enormous soft, round-celled sarcoma of the upper jaw make its appearance after a contusion which resulted fatally in eight months from marasmus, attended by frequent hæmorrhage from the internal maxillary artery. The greater part of both the upper and lower jaws was destroyed.

FIG. 210.—Follicular dental cyst of the lower jaw in a peasant thirty-four years of age (Bryk).

The body of the lower jaw in particular is, in rare cases, the seat of central epithelial tumours which probably develop from tooth-germs. The groups of epithelial cells resemble in the form and arrangement of the cells the enamel organ of embryonic teeth. These tumours, which are soft and resemble, on gross inspection, sarcomata or cysts, grow slowly, are benign, and sometimes contain in their tissues a more or less fully developed tooth. Thorough scraping out of the circumscribed tumour after resection of the surrounding bony envelope usually suffices.

Cysts of the jaws have their origin most commonly in the tooth follicles, in consequence of disturbances in the development of the dental sacs. They develop less often from the periosteum. We distinguish dentigerous and periosteal cysts of the jaw. Injuries, acute and chronic inflammation—in short, all sorts of irritation—give rise to a growth of cells which is followed by progressive cyst formation. Dentigerous cysts arise from the degeneration of a normal or superfluous tooth germ. They are rare and develop chiefly during dentition. Periosteal cysts develop most commonly, according to Partsch, in the periosteum in the region of the tooth roots—that is, from a granuloma, a fibroma, or an enchondroma. The inner wall of such cysts has an epithlial lining, which comes from the remains of the epithelium of the enamel (Brunn, Partsch). Sometimes we have to do with a cysto-sarcoma. Periodontal cysts grow very commonly in the direction of the antrum, remain closed or open, and were formerly often mistaken for dropsy or empyema of the antrum. Follicular cysts of the teeth sometimes attain an enormous size (see Fig. 210).

The treatment of cysts of the jaw consists in opening them freely (the opening being made from within the mouth, or, in case of larger tumours, from the outside), removing the anterior wall, scraping them out, and carefully searching for any teeth that ought to be removed. At the beginning of the formation of the cyst, extraction of the diseased tooth is sufficient.

Sometimes the subperiosteal removal of a portion of the lower jaw is indicated.

König and Hildebrand observed in a boy of nine years a peculiar expansion of both jaws resulting from a great number of superfluous teeth, between one hundred and fifty and two hundred in all. According to Hildebrand, four similar cases have been recorded, in which it was necessary to remove from the jaws great numbers of teeth, in the most irregular positions and situated in a panel of thin lamellæ of bone.

There are rare cases of parasitic cysts of the jaw (echinococcus or actinomycosis) (see above, page 330).

Epithelioma of the upper or lower jaw arises secondarily from the extension of an epithelioma of the skin or mucous membrane to the bone. The epithelioma which originates in the mucous membrane of the mouth, the nasal cavity, or the antrum, is especially malignant. Epitheliomata of the mucous membrane are marked by rapidly increasing local destruction of tissue and general cancerous cachexia, and usually lead to speedy death.

An exact diagnosis of tumours of the maxillary bones is not always possible during life. The enchondroma, the fibroma, and the osteoma are, for the most part, very hard benign growths, of slow development. The bluish-red epulis situated on the alveolar process, and usually resembling a fungus, also grows, as a rule, very slowly; and we have already emphasized the fact that the pronounced sarcomatous epulis is a comparatively innocuous tumour. The softer the tumour, and the more rapid its growth, attended with destruction of the bone, so much the more malignant it is, especially if combined with ulceration and sloughing of the soft parts. This is particularly the case with the carcinoma and the medullary sarcoma, which may give rise to but slight enlargement of the jaw, since everything with which the tumour comes in contact is destroyed. Primary tumours of the antrum can usually only be recognised later, when the bone has become expanded or the neoplasm has perforated its wall.

A careful and systematic examination should be made in every case of enlargement of the upper or lower jaw. It is especially important to ascertain, in case of a tumour, where this has its origin. Attention must also be paid to the condition of the facial cavities, inasmuch as tumours of the mouth, the soft palate, the throat, the nose, and the orbits often extend secondarily to the jaw. This careful investigation as to the position, extent, and character of the tumour is also, of course, absolutely necessary with reference to the operation that is to be undertaken.

The treatment of tumours of the jaws consists, as with all neoplasms, in removing them in the regular way. Benign tumours, situated upon the bone (fibroma, osteoma, enchondroma, etc.), are simply excised together, perhaps, with the involved wall of the jaw or the

portion of the bone where the tumour had its origin. If there is much involvement of the bone, or if the tumour is malignant in character and the bone destroyed, removal of the diseased part of the bone through sound tissue is necessary, or, it may be, complete excision of the upper or lower jaw. For the details of this, the reader is referred to §§ 53 and 54. Statistics show that the results of operations upon malignant tumours (carcinoma, sarcoma) are very unfavourable, permanent cures being extremely rare. According to E. Küster and Birnbaum, better results follow the removal of giant-celled sarcoma than that of any other form of malignant tumour.

§ 51. **Diseases of the Temporo-maxillary Articulation.**—Among the affections of the temporo-maxillary articulation we have already, in §§ 45 and 46, spoken of those resulting from injuries, so that it remains to consider briefly inflammations of the joint. Among acute inflammations of this joint I will mention the one which arises in the course of acute polyarticular rheumatism, that occurring during the acute exanthemata (measles, scarlet fever, small-pox), and finally that complicating gonorrhœa.

The inflammation of this joint accompanying acute articular rheumatism is usually characterized by pain when the joint is moved, and by swelling resulting from a slight serous or sero-fibrinous intra-articular and periarticular effusion. After the acute articular rheumatism has run its course the joint usually returns to its normal condition.

In connection with the acute exanthemata, suppurative inflammation occasionally ensues, resulting in anchylosis.

Gonorrhœal inflammation of the joint, the result of general infection from the disease, is usually very painful, so that chewing and speaking may be seriously interfered with. It does not usually go on to suppuration or destruction of the joint. This gonorrhœal inflammation is ordinarily of short duration, though I saw an uncommonly protracted case in which painful relapses repeatedly occurred.

Inflammation of the joint sometimes arises secondarily from inflammatory processes in its neighbourhood; or the joint, though not diseased itself, may become stiff in consequence of inflammation in the mouth, in the neighbourhood of the ramus of the lower jaw, about the wisdom teeth, etc.

Chronic inflammation of the joint is, in rare cases, the result of tubercular caries, which is seldom primary but almost always secondary to tubercular inflammation of the temporal bone. If the condyloid process is destroyed by caries, anchylosis does not always result, particularly if one of the cavities into which the joint is divided by the interarticular fibrocartilage remains intact.

Gouty inflammation of the temporo-maxillary articulation (arthritis urica) is rare.

As the result of arthritis deformans there arise sometimes in this articulation changes analogous to those in other joints—viz., defibrillation and destruction of the articular and interarticular cartilage, and at the same time new formation of cartilage and bone. In consequence of this destruction of the joint, either a flail-like joint results with characteristic creaking sounds when it is moved, and a tendency to dislocation (habitual dislocation of the jaw), or, on the other hand, more or less impairment of motion, because the deformed joint surfaces no longer fit into one another. Complete anchylosis of the joint also occurs as the result of its obliteration from the growth of connective tissue or bone (synostosis). In case of anchylosis of one joint, the other, of course, can not perform its function; still, König is right in saying that even in case of complete bony anchylosis of one joint the jaws can be separated from each other on the sound side from one half to three quarters of a centimetre in consequence of the elasticity of the lower jaw.

The treatment of inflammation of the temporo-maxillary articulation, or its sequelæ, should conform to the principles generally applicable in treating diseases of joints (see Principles of Surgery, §§ 112–124). It depends in part upon the cause of the disease. In case of acute inflammation, in addition to keeping the joint at rest, antiphlogistic measures are to be recommended. In gonorrhœal inflammation of the joint, aside from the treatment for gonorrhœa of the urethra, painting it with tincture of iodine and rubbing it with mercurial ointment are serviceable. In the case that was mentioned above, the disease disappeared permanently after protracted residence in a southern climate. Suppuration should be treated by incision, tuberculosis by scraping with a sharp spoon, and arthritis deformans may be treated by massage and active and passive motion. In case of anchylosis and in severe cases of arthritis deformans, resection of the condyloid process is to be recommended.

Resection of the temporo-maxillary joint is done as follows: The skin is divided by a longitudinal incision from two to three centimetres in length, vertically downward from the zygoma, about a finger's breadth in front of the tragus, and from the upper end of this cut a transverse incision may be made at right angles anteriorly above the zygoma. The first incision alone is often sufficient. The condyle is now freed by working inward under the zygoma. This must be done cautiously, in order that the transverse facial and temporal arteries situated close to the opening of the auditory canal, and, above all, the

facial nerve which emerges on a level with the lobule of the ear, be not injured. The head, having been exposed with the periosteal elevator, is cautiously divided with a chisel, care being taken to avoid injury to the internal maxillary artery situated on the inner side of the capsule. After drainage and suture, an antiseptic dressing is applied. The functional results of this small operation are very satisfactory.

E. Küster's method is also very serviceable (page 346).

§ 52. **Lockjaw.**—Lockjaw—that is, the impossibility of moving the firmly fixed lower jaw or separating the teeth—has already been alluded to several times—e. g., in speaking of noma, and also in connection with diseases of the temporo-maxillary joint.

Lockjaw has various causes. We have already become familiar with the condition when caused by changes within the joint while treating of anchylosis of the joint. This cause is not very frequent.

Inflammatory lockjaw, so called, is most common. It results from acute inflammation and suppuration in the neighbourhood of the jaws, especially from periostitis of the alveolar process, from inflammation of the

Fig. 211.—Bony inter-growth between the alveolar processes of the upper and lower jaws due to ossification of cicatricial bands following noma.

Fig. 212.—Lockjaw in a man seventeen years of age due to deficient size of the lower jaw with deformity of the coronoid processes.

gum in the vicinity of the wisdom teeth or any of the molars, from quinsy, and from acute inflammation of the parotid, the submaxillary, and the lymph glands, following suppurative inflammation in the neck, cheek, etc. Spasmodic lockjaw, brought about by firm contraction of the muscles of mastication, sometimes occurs, and is due to nervous causes. For the lockjaw in connection with tetanus—trismus, so called—see Principles of Surgery, § 73.

Less common than this inflammatory form is that resulting from cicatricial contraction after suppuration and loss of substance in the

vicinity of the jaws. In this category belongs the lockjaw following noma (see page 208), in which rigid bands of cicatricial tissue are formed which hold the jaws firmly together. The most serious form of lockjaw is that which arises from a bony fusion of the jaws in consequence of growth of the periosteum (see Fig. 211). This condition may come from ossification of connective tissue, after noma, for example, when the gangrenous process involves the muscles and periosteum. The movements of the lower jaw may also be prevented by bony union between the coronoid process and the zygoma, following traumatism and inflammation.

A case of special interest was observed by Langenbeck, in which lockjaw was the result of a congenital deficiency in the size of the lower jaw, with abnormal formation of the coronoid process. In this case (Fig. 212) the coronoid processes were too long and projected too far forward. They pressed against the posterior surface of the malar bone in such a way that immobility of the abnormally small lower jaw ensued. The patient was cured by resection of both coronoid processes. Küster has also called attention to smallness of the lower jaw in connection with lockjaw, especially when due to joint disease.

Treatment of Lockjaw.—The treatment of lockjaw depends, above all, upon its cause. In case of lockjaw arising from synostosis of the temporo-maxillary articulation, resection of the joint (see above, page 344), and perhaps of the coronoid process as well, is indicated (Mears, Kulenkampf, Küster). Resection was first recommended by Bottini and König. E. Küster recommends for true lockjaw resection of the joint by an incision along the border of the jaw, extending up somewhat beyond the angle, elevation of the periosteum on both sides of the ramus, and division of the ramus with a chisel in the direction of the sigmoid notch. If the condyloid process is joined by bone to the glenoid cavity, the condyle must be again divided here with the chisel and freed by prying movements. If the mouth can not be opened sufficiently wide after resection of both temporo-maxillary joints, the coronoid process must also be divided with the chisel where the temporal muscle is most tense. Helferich successfully treated a case of bony anchylosis by cutting a flap from the whole thickness of the temporal muscle with its base below, resecting the zygoma and inserting the apex of the flap between the ends of the bone which had been previously divided. This prevents the reunion of the bone. Bony anchylosis may also be treated by removal of one half of the lower jaw (Sonnenburg) or of the upper part of the ramus (Mears, see page 347).

Inflammatory lockjaw usually disappears with the cessation of the above-mentioned inflammation and suppuration in the vicinity of the

jaw. If inflammatory lockjaw is more obstinate, it is best overcome by frequent use of Roser's or Heister's mouth gag, and by instructing the patient to practise gymnastic exercises and to push a wooden wedge or screw a grooved top between the teeth. A wedge of cork is well suited for this purpose. It swells, and the patient pushes it farther and farther in between the incisors, the canines, or the molars.

In case of spasmodic lockjaw resulting from muscular contraction, electricity and massage are to be recommended.

For the treatment of trismus, see Principles of Surgery, § 73.

We have already spoken of the surgical treatment of lockjaw due to cicatricial contraction following gangrenous processes on the cheek, when dealing with plastic operations on the cheek, pages 234–239.

Bony adhesions are divided with a small saw or with the chisel, but a recurrence usually follows. A better method, therefore, is the removal of a piece of bone from two to three centimetres broad from the angle of the jaw (Esmarch) in order to secure, if possible, the formation of a pseudo-arthrosis, or artificial joint. Simply sawing through the jaw (Rizzoli) is usually insufficient, as bony union is likely to take place between the sawn surfaces.

When lockjaw is conditioned upon displacement of the ramus and upon contraction and shrinking of the muscles and ligaments in the vicinity of the coronoid and condyloid processes, resection of both joints, as mentioned on page 346, should be undertaken, the coronoid process being divided at the same time (Küster); or resection of the entire upper part of the ramus close above the opening of the inferior dental canal (Mears). For this a transverse incision along the lower edge of the malar bone is to be recommended, and from the posterior end of this a longitudinal incision downward, a finger's breadth in front of the opening of the external auditory meatus, according to the description given above on page 344 for resection of the condyle.

Recently Mears has performed resection from within the mouth. Injury to the internal maxillary artery is easily avoided by keeping close to the bone. There is more danger of cutting the inferior dental nerve.

§ 53. **Excision of the Superior Maxilla.**—Excision of the superior maxilla may be either complete or partial, depending upon whether the whole or only a part of it is to be removed. If the periosteum is preserved, the excision is called subperiosteal. Sometimes a sound maxilla is only temporarily displaced from its normal position—e. g., to make room for the removal of retro-maxillary tumours. This is called temporary or osteoplastic resection.

Complete excision or extirpation of the superior maxilla is most frequently undertaken for malignant tumours. Both superior maxillæ are removed only in rare cases.

The technique of complete excision or extirpation of the superior maxilla is as follows:

The operation is very bloody and painful—bloody on account of the division of many branches of the facial and internal maxillary arteries, and painful on account of the superior maxillary branch of the fifth nerve which runs through the upper jaw.

The entrance of blood into the air passages must be prevented as far as possible during the operation. This complication may be avoided, first, by preliminary tracheotomy and tamponing the trachea (Trendelenburg, see § 106), or the entrance to the larynx from within the pharynx; second, by operating with the head of the patient hanging over the end of the table (Rose); or, finally, third, by having the patient sit in an upright position and making use of the mixed morphine-chloroform narcosis.

Preliminary tracheotomy and tamponing the trachea (Trendelenburg), or the entrance to the larynx from the pharynx, are usually unnecessary. Operating with the head hanging downward (Rose) will surely prevent the entrance of blood into the lungs and permits a deep narcosis, but it has the disadvantage that there is considerable venous bleeding. This may, however, be much diminished by continuous compression. If the operation is performed in this way, the head of the patient is allowed to hang over the edge of the operating table, resting upon a cushion pushed under the neck. It is then drawn somewhat backward by an assistant and held there. The operator sits in front of the head as it thus hangs downward.

The method most to be recommended is the employment of the so-called mixed or morphine-chloroform narcosis and the performance of the operation while the patient sits upright, an assistant holding the head so that it inclines slightly forward. The danger of aspiration of blood into the lungs is thus surely avoided. By packing the posterior nares and by leaving the insertion of the mucous membrane of the cheek on the bone intact for the time being, the flow of blood into the mouth can be avoided during the first part of the operation. The mixed morphine-chloroform narcosis is obtained as follows: An adult is given a hypodermic injection of one third of a small hypodermic syringe of a 1-to-30 aqueous solution of morphine. He is then anæsthetized until the stage of excitement is reached, when the amount of chloroform given is decreased. In this way the patient, as a rule, experiences no pain from the operation, but is conscious, answers ques-

tions, and, more than all, controls his swallowing. He accordingly swallows the blood into his stomach, or, when told to do so, spits it out.

If the operation is performed while the patient sits upright, the danger of cerebral anæmia must be kept in mind; and if symptoms of this appear, it is better to finish the operation with the head hanging downward.

Finally, in case of very vascular tumours, preliminary ligation of the external carotid has been recommended, or, if the new growth has involved the lateral wall of the pharynx, ligation of the common carotid. The latter is to be avoided, if possible, as the circulation in the brain is thus affected. In severe cases the catgut could be laid about the carotid without tying it, so that ligation could be quickly performed, should the necessity arise.

It should be further stated with reference to the anæsthesia, that in the latter part of the operation with the patient sitting upright or with the head hanging over backward, an India-rubber tube may be introduced into the nasal cavity on the sound side and connected with a Junker's chloroform apparatus (see Principles of Surgery, page 21, Fig. 18).

Excision of the superior maxilla has, in general, as far as the operation is concerned, a favourable prognosis. Of two hundred and thirty excisions on one side, but fourteen per cent, according to Bryant, resulted fatally; and of twenty-four excisions on both sides, not one proved fatal.

The complete excision of the superior maxilla has three stages: First, division of the soft parts; second, division of the bone connections; third, arrest of hæmorrhage and suture.

In dividing the soft parts, Steno's duct, the facial artery, and the branches of the facial nerve should be avoided with all possible care. Steno's duct runs parallel with and from one and a half to two centimetres below the zygoma on the outer surface of the masseter, enters the deeper parts at its anterior edge, and terminates within the mouth opposite the first or second upper molar. A salivary fistula easily results from injury to this duct.

Of the various lines of incision for dividing the soft parts, the following may be specially mentioned (see Figs. 213, 214):

1. The median incision recommended by Dieffenbach is a longitudinal incision from the root of the nose, following the middle line of the nose and the upper lip, with a transverse one from the upper end passing to the inner canthus of the eye or along the lower edge of the orbit as far as the malar bone (Fig. 213 *a*). A right-angled or

acute-angled flap is thus formed, which is raised in a direction outward and downward.

2. The lateral incision recommended by Nélaton and Boeckel, and also used by Dieffenbach, consists likewise in cutting a triangular flap of soft parts to be raised in a direction downward and outward. It involves a longitudinal incision beginning below the inner canthus of the eye, extending along the furrow between the nose and cheek and directly downward through the upper lip, and a transverse incision from the upper end of the first along the lower border of the orbit.

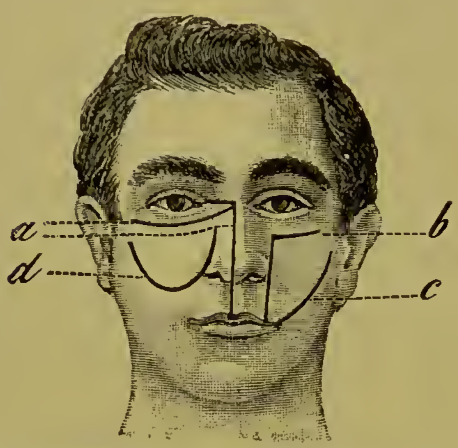


Fig. 213.—Incisions for removal of the superior maxilla: *a*, after Dieffenbach; *b*, after Böckel, Nélaton, and others; *c*, after Velpeau; *d*, after Langenbeck.

Fig. 214.—Excision of the right superior maxilla (Dieffenbach and Fergusson).

It is also a very good plan to let the longitudinal incision pass around the ala nasi and through the middle of the upper lip (Dieffenbach, Fergusson, see Fig. 214).

3. Velpeau's incision (see Fig. 213 *c*) from the corner of the mouth to the zygoma, with its convexity outward, is not to be recommended on account of the injury to the salivary duct and numerous branches of the facial nerve that it involves.

4. The flap incision used by Langenbeck (Fig. 213 *d*) consists of a semicircular incision with its base upward. It begins below the inner canthus of the eye, or still lower, at the boundary between the cartilage and bone of the nose, and ends at the malar bone. The lowest part of the incision should be on a level with a line drawn from the nostril to the tip of the ear. The salivary duct and most of the branches of the facial nerve are left intact by this method. There is, moreover, no ectropion of the lower eyelid to fear, as in the use of methods 1 and 2, for example. Of the branches of the facial nerve remaining intact, the one that supplies the orbicularis palpebrarum is the most important. If this nerve is injured, the unhappy

results of an imperfect closure of the lid ensue. This method of Langenbeck's may be designated as the best, and we shall therefore describe it more in detail. The execution of the other methods is apparent from Figs. 213 and 214, as well as from the brief description that has been given. The division of the bone is, of course, the same in all methods.

There are many variations of these four principal methods which we need not describe. The cheek incision recommended by Gensoul, which has the form of the letter H, is, properly, no longer used.

Langenbeck's incision through the soft parts begins, as has been said, below the inner corner of the eye or deeper at the junction of the bone and cartilage of the nose, runs downward along the ala nasi to the point of reflection of the mucous membrane of the cheek on to the upper jaw, then forms a curve with its convexity downward at the level of a line drawn from the tip of the ear to the nostril, and finally passes outward and upward as far as the anterior or posterior border of the malar bone or to its centre, depending upon whether the malar bone is to be wholly or in part removed or not at all. The flap thus marked out (see Fig. 213 *d*) is detached from the bone and retracted upward. It seldom happens in cases of malignant growths that the separation from the bone can be subperiosteal and the periosteum thus preserved. If the facial artery is divided, both ends are to be caught in the edges of the wound and tied. The connections of the cartilage of the nose are loosened from the lateral margins of the apertura pyriformis in order that the bony floor of the nose may be sawn through from here later. At the base of the flap that has been raised and retracted, the tarso-orbital fascia is divided transversely at the lower margin of the orbit.

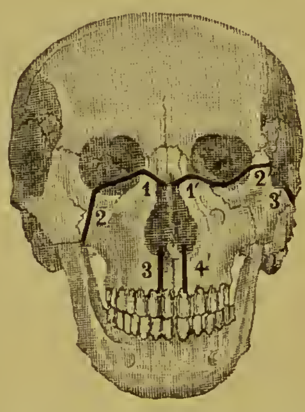


Fig. 215.—Division of the bony connections of the superior maxilla.

The bony connections of the superior maxilla are now severed with the chain saw, the metacarpal saw, or the chisel, these being with the malar bone, the frontal bone, the palate process of the other superior maxilla, and the connection of the maxillary tuberosity or the palate bone with the pterygoid process of the sphenoid. The choice of the instrument for dividing the bone is a matter of individual preference. Liston's bone forceps are much used in England, while in Germany more use is made of the metacarpal and chain saws and the chisel. As is seen in Fig. 215, the line of division of the bone runs from the apertura pyriformis through the nasal process of the superior

maxilla, through the lachrymal and ethmoid bones (see Fig. 215, 1 and 1′), then across the floor of the orbit, then either through the malar process of the superior maxilla (see Fig. 215, 2, right half of the skull) or, if the malar bone is also to be removed, through the frontal process of the malar and the zygoma (see Fig. 215, 2′ and 3′, left half of the skull). Finally, the palate processes of the superior maxillary and the horizontal plates of the palate bone are sawn through in the median line of the hard palate (3 or 4′, Fig. 215).

The division of the nasal process of the superior maxillary bone and the lachrymal and ethmoid bones is made with the chisel or the metacarpal saw corresponding with line 1 in Fig. 215, after the inferior tarsal membrane of the lower lid has been divided with a knife along the lower border of the orbit, and the soft parts of the orbit have been carefully separated from its floor with an elevator and held up by a blunt lid-holder. If the posterior part of the floor of the orbit is to be preserved, the orbit is divided with a metacarpal saw or chisel in a corresponding curved line. The division of the nasal process can also be accomplished by passing the chain saw through the bony lachrymal duct which is previously incised, and around the nasal process to the apertura pyriformis.

The next step consists in severing the connection of the malar bone with the superior maxillary (Fig. 215, 2, right half of the face). The soft parts of the orbit, which have been raised by an elevator from its lower border, are held upward by a blunt lid-holder, the anterior insertion fibres of the masseter are severed at the lower end of the malar bone, and the bone is now easily cut through with the chisel, metacarpal saw, or chain saw, the latter being carried by means of a sharply curved needle from the spheno-maxillary fissure through the spheno-maxillary fossa and around the malar process of the superior maxillary bone.

If the malar bone is also to be removed, the method is as represented in Fig. 215, 2′ and 3′ (left half of the skull). After separation of the temporal muscle, the frontal process of the malar bone is divided at 2′ with a saw or chisel from the spheno-maxillary fissure, and then the zygoma is divided from above at 3′ (Fig. 215, left half of the skull).

The final step consists in dividing the palate process of the superior maxillary bone and the horizontal plate of the palate bone in the middle line of the hard palate (Fig. 215, 3, right half of the skull, or 4′, on the left half). In Langenbeck's method the upper lip is lifted away from the jaw, the insertion of the mucous membrane upon the upper jaw is divided as far as the median line, and the apertura pyri-

formis is also opened from here. By means of a Bellocque canula (see Fig. 167, page 269) a chain saw is passed along the inferior meatus and out through the mouth after previously dividing with a knife the soft palate near the uvula and the soft covering of the hard palate. The tooth at the point where the saw divides the alveolar process should be previously removed. If a portion of the hard palate is to be preserved, the latter should be divided with a chisel in a corresponding curved line. The muco-periosteal covering of the hard palate should be retained, if possible, in order to shut off the wound cavity from the mouth. In this case this covering is separated by making an incision down to the bone from the inner incisor to the last molar, close behind the teeth, and then from this incision raising the entire covering as far as the median line by means of a periosteal elevator, just as in performing uranoplasty. The soft palate on this side is divided from the same incision with a two-edged knife curved on the flat, so that the soft palate and the covering of the hard palate form one flap. The upper lip is now drawn well forward, and the hard palate divided in the middle line with a saw or chisel.

After the above-mentioned bony connections have been severed in the manner described, the superior maxilla, or rather the maxillary tuberosity, is still joined to the pterygoid process. This connection is easily severed by seizing the jaw with forceps, or inserting an elevator in the furrow made by the saw in the malar bone, and using it as a lever. The jaw, thus loosened, is then entirely removed, the soft parts which still hold it—viz., the soft palate, the pterygoid muscles, etc.—being cut with scissors, or, better, twisted off in order to diminish the hæmorrhage from the branches of the internal maxillary artery.

The arrest of hæmorrhage includes ligation of the infraorbital, which is divided at its entrance into the infraorbital canal, the pterygopalatine, and the internal maxillary arteries. The facial, the transverse facial, and the superior and inferior coronary arteries are tied earlier, when the external soft parts are divided.

Finally, the wound cavity is packed with strips of iodoform gauze, the ends of which are brought out through the nose. The edges of the wound are united by several interrupted sutures of fine silk and by a continuous catgut suture. If the muco-periosteal covering of the hard palate has been preserved, it is sutured to the inner surface of the cheek. In the same way, as recommended by Nussbaum in excision of the lower jaw, a wire framework might be laid in the cavity for a time and secured by sutures. The object of this is to lessen functional disturbance and disfigurement (Helferich). After complete excision

of the upper jaw, Bardenheuer remedied the defect in the hard palate by immediately implanting a flap from the forehead and one from the mucous membrane of the cheek. These flaps from the soft parts are laid one upon the other with their wound surfaces in contact. Some bone may also be included in the frontal flap.

If a necrotic upper jaw resulting from phosphorus necrosis, for example, is to be removed, it can be done more easily by taking out a wedge-shaped piece from the middle in order to make the rest of the jaw movable and allow its extraction with forceps.

After-treatment.—In the after-treatment particular attention must be paid to possible secondary hæmorrhage. The development of septic pneumonia, which was formerly so frequent in consequence of the aspiration of pus, is best prevented by packing with iodoform gauze. Nourishment is given for a time through the stomach tube.

The outward disfigurement after excision of the upper jaw is not so great as might be imagined. The cavity is filled by granulation tissue and covered in by the outer skin, which is supported by the malar bone and the nose. The defect can be remedied about three weeks after the operation by the insertion of an artificial plate of rubber and artificial teeth. It is of course better if the mouth is entirely shut off by preserving the muco-periosteal covering of the hard palate. The preservation of the floor of the orbit is naturally important, in view of possible functional disturbances of the eye. If the entire floor is removed, the eyeball may sink into the wound cavity and suppurate, and in consequence of cicatricial distortion of the ball, diplopia may result. Sinking of the bulb may be prevented by the insertion of a celluloid plate.

Fig. 216.—Excision of both superior maxillæ for carcinoma in a man forty-four years of age (Braun).

Complete excision of both superior maxillæ, first performed by J. Heyfelder in 1844, is done essentially in the same way as that on one side. Either Langenbeck's curved incision, or the lateral angular incision recommended by Böckel, Nélaton, or Fergusson, as shown in Figs. 213 and 214, page 350, is made on both sides, or Dieffenbach's median incision may be used with advantage. In the latter case transverse incisions are made from the upper end of the median longitudinal incision to the inner corners of both eyes, or along the lower margin of the orbit to the neighbourhood of the outer corners of the eyes. The bone connections are then severed as described above, the vomer being best divided with Liston's forceps. The muco-periosteal covering of the hard palate is preserved, if possible. To this end it is raised by an

elevator along a curved incision close behind the teeth, and the insertion of the soft palate is then, as above, entirely separated from the hard palate on both sides. Fig. 216 represents a case of excision of both superior maxillæ performed by Simon for carcinoma.

Partial excisions of the upper jaw are, of course, manifold. The removal of the alveolar process is the one most frequently undertaken. Removal of the body of the upper jaw with preservation, particularly, of the hard palate or the border of the orbit is classed among partial excisions. Resection of the anterior wall of the jaw (trephining the antrum) is likewise to be regarded as a partial excision. In all atypical partial excisions the chisel and Luer's or Liston's bone forceps are the instruments most used.

The alveolar process is most easily removed by an incision from within the mouth. The gum is pushed back and the diseased portion of the bone is chiselled out or cut out with bone forceps. If the adjoining part of the body of the jaw is also to be removed, this can be done from within the mouth in the manner just described. More room is secured in such cases by dividing the upper lip in the median line, freeing the soft parts from the bone with knife and periosteal elevator, and finally dividing the bone with a saw or chisel. If necessary, the external incision through the upper lip may be extended around the ala of the nose and upward as far as one wishes. If the piece of bone to be removed from the alveolar process and the body of the jaw is situated farther back, a small incision may be made in the cheek running obliquely upward and outward from the corner of the mouth, care being taken, of course, not to wound Steno's duct and the facial nerve.

Partial excision of the body of the upper jaw, with preservation of the hard palate or the border of the orbit, can be accomplished by means of Langenbeck's curved incision (Fig. 213 *d*) which has been described above. If the hard palate is to be preserved, the outer wall of the jaw is divided in a horizontal direction outward and backward to the pterygoid process of the sphenoid bone. For this purpose a metacarpal saw, chisel, or straight bone forceps is used. If the orbital plate is to be preserved, the bone is divided beneath the border of the orbit with a chisel or small saw.

In partial excisions, also, any defects, particularly in the alveolar process, may be remedied by artificial teeth.

For resection of the anterior wall of the jaw, or trephining the antrum, see page 336.

Osteoplastic resection of the upper jaw is undertaken for exposure by temporary removal of the bone, of the pharyngeal cavity, the orbit, and the spheno-maxillary and temporal fossæ, in order to facilitate the excision, for example, of retro-maxillary tumours, naso-pharyngeal polyps, etc. The portion of the jaw in question is turned back like the cover of a box and afterward returned to its normal position. To make this opening possible, the part of the jaw concerned is not separated from all its bony connections, but at one point a bridge is left consisting of bone, periosteum, and skin. This bridge of bone is then

broken in so as to allow the resected portion to be turned out. The line of separation of the bone corresponds to the incision in the soft parts. The operation is done outside the mouth, the hard palate and the alveolar process being preserved to prevent permanent defects. The operation is not without danger, owing to the hæmorrhage which is often marked. In thirty-nine cases death resulted eight times during or immediately after the operation (Lincoln).

The best method in osteoplastic resection of the upper jaw is that of Langenbeck. Soft parts and bone are divided as represented in Figs. 217 and 218. The nutrient bridge is in the region of the frontal process of the superior maxillary bone.

The operation is best performed by having the division of the body of the jaw immediately follow the lower incision in the soft parts; then the soft parts and bone connection at the malar bone are divided, and finally the soft parts and bone at the lower wall of the orbit, in the direction of the upper incision.

Langenbeck's incision through the soft parts, which is shown in Fig. 217, begins on the boundary between the cartilage and bone of the nose, or somewhat lower, at the outer end of the nostril, runs across the cheek on the lower edge of the malar bone, upward over the anterior border of the zygoma, then, near the outer corner of the eye, bends inward in a curve or at right angles, and runs along the border of the orbit to a point beneath the inner canthus. This incision in the soft parts goes through to the bone, which is correspondingly divided (see Fig. 218). The lower part of the incision is made first, and then the soft parts are divided from the maxillary tuberosity backward to the posterior palatine canal. A small metacarpal saw is inserted in the latter as far as the spheno-maxillary fossa, the soft parts being retracted and the posterior nasal artery carefully guarded, and the posterior part of the nasal cavity is thus reached. To protect this cavity from the point of the saw, an elevator is carried along the septum as far as the pharynx, and the body of the jaw is now sawn through along the lower incision to the apertura pyriformis. One makes sure in advance, with the aid of the left forefinger, that the elevator has entered the pharynx.

Fig. 217.—Osteoplastic resection of the upper jaw.

The second incision begins below the inner corner of the eye and runs along the lower border of the orbit to the neighbourhood of the outer corner of the eye, and then, in a curve or at right angles, into the

outer end of the lower incision. The connection of the superior maxillary with the malar bone is then divided through the spheno-maxillary fissure by means of a metacarpal or chain saw, and the lower wall of the orbit is thereupon divided with the chisel or metacarpal saw, following the upper part of the incision in the soft parts and guarding the lachrymal sac. Before this is done, the soft parts of the orbit, including the periosteum, are freed with a knife and elevator and drawn upward with a blunt retractor.

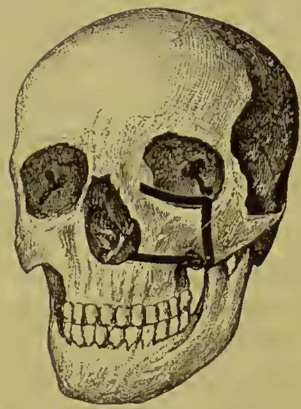


Fig. 218.—Line of division of the upper jaw in osteoplastic resection.

The jaw is pried forward by inserting an elevator in the fissure made by the saw in the malar process of the superior maxilla or in the spheno-maxillary fossa. The connection with the frontal and nasal bones at the nutrient bridge is then broken in and the now completely loosened portion of the jaw is displaced upward and inward. To render the breaking of the bone at a particular point of the nutrient bridge easier, the nasal process of the superior maxilla may be partially divided with the chisel subcutaneously and subperiosteally.

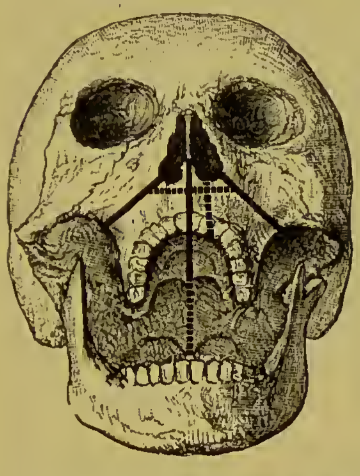


Fig. 219.—Kocher's osteoplastic resection of both superior maxillæ. .... Incision through the soft parts. —— Division of the bone.

After displacing the jaw a view is gained of the retro-maxillary cavities, the nasal cavity, the pharynx, the spheno-maxillary fossa, the temporal fossa, and the orbit. After the removal of any tumour that may be present, the portion of the jaw that has been temporarily resected is replaced in its normal position. Bone sutures are usually unnecessary, the exact coaptation of the soft parts by sutures being sufficient. If one desires to displace both the superior maxillary and malar bones upward and outward, the nutrient bridge may be made at the zygoma, and, by breaking this, the freed portion of the jaw with the malar bone may be displaced outward at a point somewhere near the line of articulation of the zygomatic process of the temporal bone with the malar bone.

Kocher exposed the naso-pharynx in a case of recurrent sarcoma of this cavity by the following method of osteoplastic resection of both superior maxillæ (Fig. 219): Mixed morphine-chloroform narcosis was used and the head of the patient allowed to hang over the end of the table. The upper lip was divided

from the left nostril downward. The reflection of the mucous membrane above the alveolar border was then divided transversely down to the bone. After packing the wound for a short time the chisel was made to sever transversely first one and then the other superior maxillary bone above its alveolar process on a level with the anterior nasal process. After again packing the wound for a short time the alveolar process and hard palate were divided in the median line and the two lower portions of both superior maxillary bones were retracted with sharp hooks. The mucous membrane of the floor of the left nasal fossa was then divided and the vomer forced over to the right side. This permitted an excellent inspection of the whole naso-pharyngeal space. As the tumour was adherent to the insertion of the soft palate, the latter was also divided in the median line. The tumour was removed by means of a periosteal elevator and thermo-cautery, the hæmorrhage arrested, and the cavity packed. The parts were brought back to their normal position and secured by suture of the bone and soft parts. No disfigurement resulted.

§ 54. **Excision of the Inferior Maxilla.**—Operations upon the lower jaw, like those upon the upper jaw, are attended with great loss of blood, and the aspiration of blood into the air passages must here also be carefully avoided. This is best and most simply accomplished by the use of the mixed narcosis and upright position of the upper part of the body, with the head inclined slightly forward (see also pages 348 and 349).

Operations on the lower jaw include disarticulation of half the jaw; complete removal of the jaw, which is rare; excision of the alveolar process; excision of the middle or the lateral portions of the jaw; and, finally, resection of its condyloid process (see page 344).

The operation for excision of one half of the inferior maxilla has three stages: 1. Incision through the soft parts along the lower border of the jaw and separation of the soft parts on the anterior and posterior surfaces of the jaw. 2. Sawing through the bone and disarticulation of half the jaw. 3. Arrest of hæmorrhage and suture. Necrosis and tumours most frequently call for this operation.

The incision through the soft parts along the lower border of the jaw runs from the angle of the jaw somewhat beyond the middle of the chin. It should extend very little, if at all, beyond the angle of the jaw, for fear of injuring Steno's duct and the facial nerve. The jaw may be sawn through at the outset from a small incision, so as to make the portion of bone that is to be taken out more movable. This method has been used by Langenbeck and others. The incision along the lower border of the jaw is made down to the bone, and the facial artery which is thus divided is tied. A vertical incision in the median line of the chin or through the lower lip is usually unnecessary in cases of necrosis, and only necessary in cases of tumour when

the growth is extensive. Through the lower incision along the border of the jaw all the soft parts are now freed from the anterior and then from the posterior surface of the jaw with the knife and periosteal elevator. The insertion of the masseter and the alveolar mucous membrane on the anterior surface, and the pterygoid muscle on the posterior surface, are freed with the knife, the rest being done with an elevator. The alveolar mucous membrane, in case it can be preserved, must be divided as smoothly as possible and in a straight line, as the edges of the mucous membrane are sutured together after removal of the jaw. It is usually impossible in the case of tumours to preserve the periosteum. After the soft parts have been completely separated and any tooth that stands in the way has been extracted, the jaw is divided at the chin with a chain saw. The soft parts, especially those in the neighbourhood of the parotid, are now drawn upward with sharp retractors by an assistant, while the operator seizes the half of the jaw that is to be removed with his left hand or with bone forceps and draws it firmly downward. The separation of the soft parts on the ramus is now completed with the elevator and the insertion of the temporal muscle on the coronoid process is divided with the knife, or the coronoid process is cut through with rongeur forceps. The jaw now hangs only by the joint capsule and the upper fibres of the external pterygoid muscle. These soft parts are simply torn away by twisting the jaw a few times, injury to the internal maxillary artery which runs along the inner side of the joint capsule being thus best avoided. The inferior dental artery will usually have to be tied, as well as some branches of the internal maxillary. Any bleeding from the divided end of the inferior dental artery in the sawn surface of the jaw may, if necessary, be arrested by the thermo-cautery. After the inferior maxillary nerve which has been torn away is cut as near its origin as possible, the edges of the mucous membrane are united by continuous catgut sutures. The wound in the skin is drained, particularly at its posterior part reaching to the glenoid cavity, carefully sutured, packed, if necessary, and covered with an antiseptic dressing. For the next few days the patient is fed through a stomach tube.

In case of phosphorus necrosis the removal of half the jaw is very simple. It can often be accomplished with blunt instruments after dividing the soft parts, especially along the ramus, since the necrotic jaw forms a complete sequestrum surrounded by an involucrum.

The excision of the entire inferior maxilla is usually performed on the living person for phosphorus necrosis only. The method is essentially the same as that for the removal of half the jaw—that is, the disarticulation of each half is done in the manner described above,

after the jaw has been sawn through in the middle line. The tongue is secured by a loop of thread (see below).

Partial excisions of the lower jaw include those of the alveolar process, the removal of larger or smaller pieces from the middle and sides of the jaw, and, finally, excision of the condyloid process.

Excision of the alveolar process is performed in much the same way as upon the upper jaw. The lower lip is drawn downward; the insertion of the mucous membrane on the alveolar process is divided and, together with the gum, is separated from the bone with an elevator. After the teeth at the place where the bone is to be removed have been extracted, the portion of bone is cut away by the use of Luer's or Liston's forceps. If additional bone from the anterior or posterior surface of the jaw is to be taken away, the chisel is used in preference. The portion of the alveolar process situated most posteriorly may be removed subperiosteally through an incision in the skin near the angle of the jaw.

In the removal of larger or smaller pieces of bone from the continuity of the jaw, the bone is exposed through an incision in the soft parts along the lower border in the same way as in the removal of a half of the jaw, and then the exposed portion is sawn through on both sides.

The removal of the middle piece of the lower jaw may be accomplished either from within the mouth, after the gum, the mucous membrane, and all the soft parts on the anterior and posterior surface have been detached with the knife and periosteal elevator, to a point beyond the lower border of the jaw, or the lower lip may be divided vertically in the median line and the soft parts separated from the bone, through this incision. If the entire middle piece as far as the angle of the jaw has to be removed, the soft parts are detached from the bone through an incision along the lower border, just as in the disarticulation of half of the jaw, and the bone is sawn through on both sides at the angle, after making, if necessary, a vertical incision from three to four centimetres long on both sides.

In the removal of the middle piece of the lower jaw the insertion of both genio-glossi muscles is divided. In consequence of this, the tongue loses its point of attachment and easily falls back toward the pharynx and entrance to the larynx, causing suffocation. To avoid this danger, the tongue must be secured for the first four to six days, and the patient carefully watched during sleep. The tongue is best secured by means of a loop of thread passed through its substance which is fastened to the cheek with adhesive plaster. It is surer if, in addition to this, the free edge of the floor of the mouth is sutured to the lower edge of the incision in the skin or secured to the skin of the chin. In the latter case a mattress suture (after Mosetig-Moorhof) is used. A double thread of silk is provided with a needle at each end, both of which are passed perpendicularly through the floor of the mouth and the skin of the chin on each side of the frenum and about one centimetre apart. The two threads are then fastened on each side to a little plate of wood which lies on the skin of the chin and is supported by the parts of the jaw that have been preserved.

In excision of the lateral portion of the body of the jaw and of the ramus the soft parts are likewise detached with a knife and elevator through an

incision from the lower border or from the angle of the jaw, and the rest of the operation is the same as in the disarticulation of one half the jaw. Mikulicz has recommended excision of the ramus for the extirpation of sarcoma or carcinoma of the tonsils, and I have performed this operation several times with good results.

For resection of the condyloid process for synostosis, see page 344.

Temporary Resection of the Lower Jaw has been recommended in order to secure access to the mouth for the removal, for instance, of malignant tumours of the floor of the mouth, the tongue, or the tonsils. To this end, the lower jaw has been divided in the median line of the chin (Roux, Sédillot, and others), or bilaterally (Billroth), or unilaterally (Langenbeck). Of these methods, the lateral division of Langenbeck's is alone serviceable if a carcinoma of the posterior portion of the tongue or of the tonsils is to be removed (see § 61, Extirpation of the Tongue).

There are various ways in which the defect arising from partial excision of the lower jaw may be remedied after the operation. This may be done, for instance, by means of a wire framework, after Nussbaum, or by means of a prothesis made of gold or aluminium bronze wire, with winglike attachments which are fastened to the ends of the divided jaw. India-rubber devices (Claude Martin) are less desirable. After resection of the lower jaw in continuity, Bardenheuer took a flap consisting of skin and bone from the forehead with a long, broad pedicle situated in front of the ear and implanted it in the floor of the mouth in such a way that the skin faced upward. Wölfler took a flap of skin from the neck, together with a piece of the clavicle.

CHAPTER VII.

INJURIES AND DISEASES OF THE MOUTH, FAUCES, AND PHARYNX.

I. Methods of Examination; Mouth Gags.

II. Diseases of the Mucous Membrane of the Mouth: Catarrhal stomatitis, ulcerative stomatitis.—Vasomotor neuroses.—Thrush.—Other inflammations of the mucous membrane of the mouth.—Emphysema of the cheek.—Erysipelas.—Syphilis.—Tuberculosis.—Diseases of the gums and teeth (see § 47, page 310 ff).

III. Injuries and Diseases of the Tongue and the Floor of the Mouth; Malformations: Adhesions of the tongue.—Tongue-tie.—Abnormally long frenum ("swallowing the tongue").—Lingua bifida.—Hypertrophy.—Atrophy of the tongue.—Absence of the tongue.—Stuttering. Injuries and Inflammations of the Tongue: Wounds.—Burns.—Foreign bodies.—Acute inflammations of the tongue.—Tuberculosis.—Syphilis.—Actinomycosis. Other Diseases of the Tongue: Neuroses and neuralgia of the tongue.—Tumours of the tongue and the floor of the mouth (ranula, dermoids, epithelioma, etc.).—Operative treatment of epithelioma of the tongue.—Artificial tongue after complete removal.—Ligation of the lingual artery.

IV. Injuries and Diseases of the Soft Palate, the Tonsils, and the Pharynx: Congenital clefts and acquired defects of the hard and soft palate.—Uranoplasty.—Staphylorrhaphy.—Injuries of the soft palate, pharynx, and tonsils.—Foreign bodies. Inflammatory Processes: Acute inflammations (catarrh, vasomotor neuroses, suppuration, abscess, erysipelas "acute infectious phlegmon of the larynx").—Diphtheria and croup.—Chronic inflammations (chronic pharyngitis and tonsillitis).—Amputation of the hypertrophied uvula.—Removal of the tonsils.—Pharyngomycosis leptothrica.—Bursitis pharyngealis.—Tuberculosis.—Syphilis.—Tumours of the palate, pharynx, and tonsils.—Naso-pharyngeal polyps.—Retromaxillary and retro-pharyngeal tumours.—Pharyngotomy.—Excision or resection of the pharynx and larynx.

§ 55. **Examination of the Mouth, Fauces, and Pharynx.**—The examination of the mouth begins with an inspection of the lips, the mucous membrane of the cheeks, the teeth, and the gums, by everting the lips and drawing them outward. For a thorough examination of the hard and soft palate, the tonsils, and the pharynx, the mouth must be opened as wide as possible. The tongue is pressed down by the finger, the handle of a spoon, or a tongue depressor (see Fig. 220). These instruments must not be pushed too far back, lest by touching the posterior wall of the pharynx they induce vomiting. When the patient is made to say *a*, as in the word tar, the soft palate rises, unless paralyzed, and one gets a good view of the tonsils and the posterior wall of the pharynx. The other parts of the mouth, especially the floor of the mouth, the hard palate, etc., must likewise be systematically examined.

The mouth has frequently to be opened by force, as in the case of obstinate children, or in lockjaw or narcosis.

The mouth of an obstinate child can be opened by simply pushing the lower lip over the incisor or the molar teeth. The child involuntarily opens

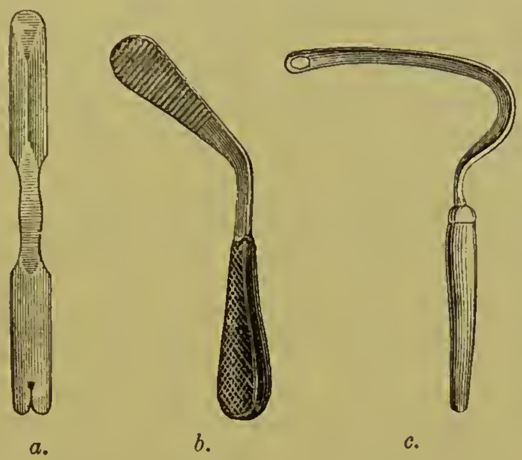


Fig. 220.—Tongue depressors: *a*, tongue depressor for a pocket case; *c*, Fraenkel's tongue depressor.

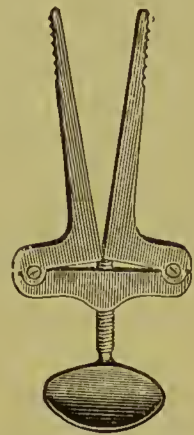


Fig. 221.—Heister's mouth gag.

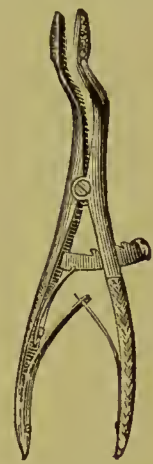


Fig. 222.—Roser's mouth gag.

his mouth in order to free the lip, which is pinched between the teeth and the physician's finger. A simple wooden wedge, or Heister's mouth gag (see Fig. 221), or Roser's mouth gag (see Fig. 222), may be used for forcibly opening the mouth.

Fig. 221 represents Heister's mouth gag when open. By turning the screw the blades are forced apart. Fig. 222 shows Roser's mouth gag, also,

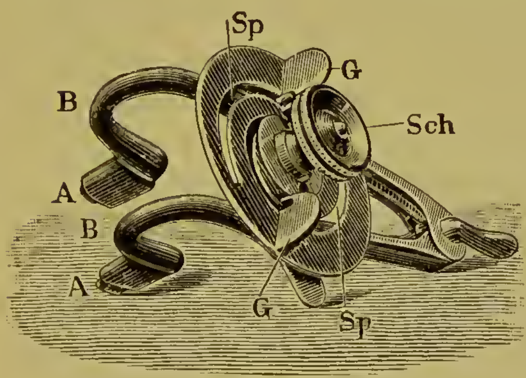


Fig. 223.—English mouth gag.

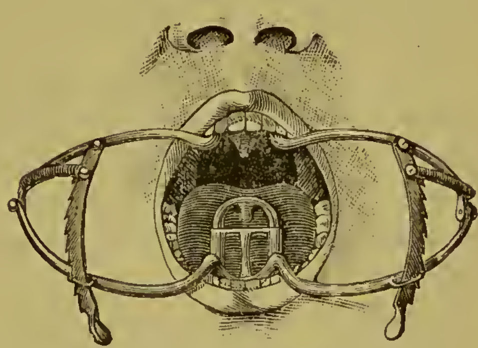


Fig. 224.—Whitehead's mouth gag.

when open. By pressing the handles together, the blades are forced apart and held fast by the ratchet in any position desired.

The second group of mouth gags consists of those which serve to hold the mouth open for a longer time during an operation in the mouth or pharynx. For this I have recently made exclusive use of a very excellent English instrument (see Fig. 223). By turning both the handles G in the spiral passage Sp, the ends of the branches A A lying between the teeth are pressed apart and held in any desired position by the screw Sch. The instru-

ment retains its position automatically. By placing such an instrument in each corner of the mouth, these can likewise be held back. If desired, the two instruments may be fastened together at the back of the neck by a band.

Whitehead's gag (Fig. 224), which is a modification of Thomas Smith's is also very serviceable. The instrument forces the teeth apart, and, by means of a plate, depresses the tongue; the toothed clasps catch in the guards. When the handles upon the tooth clasps are pressed toward the median line, the teeth of the instrument lose their hold, the whole instrument falls together, and it can be taken from the mouth.

König's mouth gag consists of two grooved plates which are laid upon the teeth. The plates can be separated by pressure upon the handles, and then held automatically in this position.

To draw the corners of the mouth backward, the retractors shown in Fig. 238, page 401, may be used. These are fastened by a band passed around the neck.

We have already (§ 39, page 266 ff), under the subject of rhinoscopy, described the examination of the pharynx by pharyngoscopy or pharyngo-rhinoscopy and palpation.

A number of diseases of the tonsils and pharynx can be diagnosed at once from the disturbances of speech, and from the manner of breathing, without inspection or palpation. Patients, for example, with enlarged tonsils always speak as though they had "a lump in the throat." Such patients snore, moreover, in their sleep. Precisely the same disturbances of speech and breathing may be caused by other swellings and tumours in the pharynx and its vicinity. Patients with perforation of the hard palate have a strikingly nasal speech, whereas those whose communication between the nose and pharynx has been closed by tumours, for instance, or adhesions between the soft palate and the posterior wall of the pharynx, can not pronounce the nasal sounds *m* and *n*, but substitute for them *b* and *d*.

§ 56. **Diseases of the Mucous Membrane of the Mouth.**—Among the diseases of the mucous membrane of the mouth we mention first catarrhal inflammation (stomatitis catarrhalis) resulting from mechanical or chemical irritation, from decayed teeth, or from uncleanliness, particularly after operations within the mouth and during the course of febrile diseases. In catarrhal stomatitis the mucous membrane is hyperæmic; the epithelium becomes desquamated (desquamating catarrh); the increased secretion contains at first but few cells, but later, owing to admixture of the epithelium and the white corpuscles of the blood, it becomes richer in cells. The swelling is either more or less uniform or more confined to certain areas. Vesicles often form as the result of the abundant secretion and the swelling. These are found particularly on the lips, cheeks, and tongue; and after they burst, small erosions or superficial ulcers appear.

The treatment of catarrhal stomatitis is, above all, prophylactic—that is, after operations within the mouth and during the course of in-

fectious diseases the mouth must be frequently cleansed with a tooth-brush and with disinfecting solutions, such as chlorate of potash, boric acid, and permanganate of potash. If catarrhal stomatitis is already present, precisely the same course is pursued. Superficial ulcers are treated with nitrate of silver, either in the form of the stick or in solution, tincture of iodine, or one-per-cent chromic acid.

Ulcerative stomatitis, which has already been mentioned, appears especially in badly nourished, uncleanly persons when suffering from febrile diseases, also in connection with scurvy, and from the effects of mercury, lead, phosphorus, and copper. It is most frequently caused by the action of microbes, since the greatest variety of bacteria, mould fungi, and fermentation fungi are present, especially when the mouth is not properly cleansed, and during the course of infectious diseases. Mercurial stomatitis is observed, for instance, during the inunction treatment of syphilis, in case the patient neglects to cleanse his mouth sufficiently, or smokes, or is constipated. Mercurial stomatitis always starts from the gum, beginning with swelling and loosening of the same, and frequently with slight bleeding. A greenish coating is generally found on the teeth at the edge of the gum. If the injurious influence of the mercury continues, ulceration follows, which may even be combined with necrosis of the bone. The swelling in the mouth is usually not extreme. A characteristic of mercurial stomatitis is the very offensive breath of the patient, and there is usually, also, a profuse excretion of saliva.

Noma is a special form of ulcerative stomatitis originating in the mucous membrane of the cheek. This has already been described (page 208).

The treatment of all forms of ulcerative stomatitis consists in immediate removal of the injurious influence that is at work—the mercury, for instance, in the inunction treatment of syphilis; in careful cleansing of the mouth by the use of disinfecting solutions, such as chlorate of potash, boric acid, and permanganate of potash; in painting the parts with the same solutions, or with nitrate of silver (1 to 100 or 1 to 50), with iodine, or one-per-cent chromic acid. Larger and deeper ulcers are cauterized with the nitrate-of-silver stick.

The temporary swelling and hyperæmia of the mucous membrane of the mouth and throat, which are observed especially in neurasthenic persons, are of particular interest. In consequence of the slightest irritation, particularly after errors in diet and nervous excitement—of a mild character often—there follow swelling and hyperæmia of the mucous membrane of the lips, the mouth, and the throat, which disappear after some hours, or perhaps after two or three days, and which may be regarded as a vasomotor neurosis. A characteristic case which I saw was that of a pupil in a preparatory school,

who very frequently, before an examination or after taking certain kinds of food, was attacked in this way. After he had successfully completed his examinations at graduation he was permanently freed from his unpleasant affliction.

In addition to proper local treatment for this vasomotor neurosis, a general strengthening mode of life, suited to overcome neurasthenia, is strongly to be recommended.

Thrush is characterized by the formation of gray or grayish-yellow deposits, with a red margin, upon the catarrhally inflamed mucous membrane, varying in size from a pinhead to that of a pea. They form single or multiple whitish deposits, which coalesce to form larger areas. The mucous membrane of the tongue, the upper and lower lip, and the throat are most often affected. Thrush is due, according to Bohn, to a fibrinous exudation between the connective tissue and epithelium. The exudation is either absorbed again or supplanted by the regenerated epithelium, or, after desquamation of the epithelium, ulceration takes place. According to Eugen Fränkel, we have to do with a pseudo-diphtheritic affection, in Weigert's sense—that is, with the formation of a fibrinous exudation (stomatitis fibrinosa, Henoch) that involves destruction of the epithelium. Teething children are most subject to thrush. Thrush is caused by saccharomyces albicans.

Thrush is to be distinguished from aphthæ (stomatitis aphthosa), which have very properly been compared to eczema impetiginodes of the skin. Spots are found reaching the size of a pea, due to a fibrinous exudate between the epithelium and submucosa. These remain isolated or coalesce, and may lead to corresponding losses of substance. Aphthæ are almost always caused by the milk of animals with hoof and mouth disease.

The treatment of thrush and aphthous stomatitis consists in mechanical cleansing of the mouth, gargling and painting the interior with chlorate of potash, or, still better, permanganate of potash, which acts almost as a specific. Ulcers are treated with silver nitrate in solution (1 to 100 or 1 to 50), or in the form of the stick, or with one-per-cent chromic acid. Above all, good milk must be provided.

Vesicular and pustular inflammations of the mucous membrane are, moreover, observed in small-pox, chicken-pox, pemphigus, hoof and mouth disease. In the latter disease small vesicles containing a cloudy fluid are found, and after they burst dark-red erosions appear. The infection is most frequently the result of drinking the milk of diseased animals unboiled.

J. Hutchinson observed several cases of chronic ulcerative stomatitis with a simultaneous diseased condition of the skin and nails, almost exclusively in men over forty years of age. Of the six cases, three proved fatal. The course of the ulcerative stomatitis is similar to that of mercurial stomatitis. Swellings are observed on the skin of the hands and feet similar to chilblains, and an eruption similar to pemphigus, eczema, psoriasis, lichen, or erythema multiforme. Suppurative onychia attacks the nails and they finally fall out. The disease, the causes of which are unknown, has a certain resemblance to severe cases of pemphigus, lichen ruber, and similar affections, which are usually combined with extreme inanition.

Emphysema of the Cheek.—Circumscribed collections of air in the cheek may arise from injuries to the mucous membrane of the cheek or from ulcer-

ative processes, especially when Steno's duct is opened. Deichmüller observed an air tumour of this sort in the cheek of a glass blower. In such cases simple incision usually leads to recovery.

Among the other numerous diseases of the mucous membrane of the mouth, aside from thrush and most forms of ulcerative stomatitis, arising in the course of infectious diseases, are to be included erysipelas, croup, diphtheria, tuberculosis, actinomycosis, and syphilis.

Erysipelas of the Mucous Membrane of the Mouth may arise primarily in the mouth, following wounds or ulcers, and may spread from here to the mucous membrane of neighbouring cavities, or attack the skin of the face. The reverse is more frequently the case, primary erysipelas of the face spreading to the mouth. The swelling, especially that of the tongue and the floor of the mouth, the soft palate, and the entrance to the larynx, may be so great as to cause danger of asphyxia, and so necessitate tracheotomy. In rarer cases, erysipelas of the mucous membrane makes its way along the air passages as far as the lungs, causing here erysipelatous pneumonia.

The therapy of erysipelas of the mouth consists in the antiseptic treatment of any wound or ulcer that may be present, and in the use of ice internally and externally and antiseptic mouth washes. In case of increasing swelling, superficial scarification with a pointed knife is advisable. If there is danger of asphyxia, tracheotomy is indicated.

For croupous and diphtheritic inflammation of the mucous membrane of the mouth I refer to § 67, page 411 ff. We shall take up tuberculosis (§ 59, page 374; § 68, page 428) in connection with diseases of the tongue, the palate, and the tonsils. Actinomycosis also, which has already been mentioned under Diseases of the Jaws, will be described in connection with diseases of the tongue. For a more complete description of actinomycosis, see also Principles of Surgery, § 86.

Syphilis.—We shall also speak more in detail of syphilis of the mucous membrane of the mouth under Diseases of the Tongue, the Palate, and the Pharynx (§ 59, page 375; § 68, page 429). The following brief general statements will suffice here:

Syphilis causes primary, secondary, and tertiary affections of the mouth. The primary syphilitic affection is observed especially on the lips, where the same characteristic indurations and ulcers are formed as on the prepuce. The secondary manifestations of syphilis are analogous to those on the skin—that is, there appear here also macules, papules, and ulcerations. Macular syphilides take the form of a circumscribed or more diffuse hyperæmia (erythema), especially on the soft palate and the tonsils (angina erythematosa syphilitica). Syphilitic erythema

often results in the formation of superficial erosions and fissures, with a whitish coating. Syphilitic papules are flat, red, circumscribed elevations of the mucous membrane of the mouth, which appear sometimes in great number on the tongue, the lips, the cheeks, and the palate. They disappear as such under proper treatment, or change into nodules with a whitish coating which may break down and form ulcers. Broad condylomata (condylomata lata) are indurations of the mucous membrane in the form of papules, caused by serous transudation and cellular infiltration within the same. These are by no means so common in the buccal cavity as about the anus and vulva.

In the later stages of syphilis gummata make their appearance in the form of circumscribed nodules the size of a pea or bean, or even larger, in the submucosa, or as more diffuse processes. From the breaking down of these nodules, which are at first hard and then become softer, corresponding ulcers are formed which frequently spread, and, as a rule, heal slowly under local and constitutional treatment. The tongue and the hard and soft palate are the favourite locations for gummata. Gummata of the tongue may be mistaken for epitheliomata. Perforations of the hard palate, which take place chiefly from within the mouth or nasal cavity, are due to circumscribed or diffuse gummatous periostitis.

The treatment of syphilis of the buccal cavity consists in proper local treatment and, above all, in an antisyphilitic general treatment (mercury, iodide of potassium), for a description of which the reader is referred to Principles of Surgery, § 84.

§ 57. **Malformations of the Tongue.**—Of these malformations we mention first fixation of the tongue in consequence of congenital bands and folds of mucous membrane, which draw the borders of the tongue toward the floor of the mouth, or in consequence of acquired cicatricial bands, resulting from ulcerative or suppurative processes. In rare cases of defective development of the tongue, or perhaps also of intra-uterine disease, congenital adhesion of the entire tongue with the floor of the mouth or the lower jaw has been observed. Sometimes this union of the tongue with the floor of the mouth is only superficial, as between the labia in newborn children.

The treatment consists in dividing the bands and adhesions with scissors. Thicker vascular bands may be divided with the cautery or tied off with catgut. A superficial union may be broken up by the finger, probe, or spatula.

This congenital or acquired fixation of the tongue is to be distinguished from those cases which are ordinarily designated as tongue-tie, and which are caused by a frenum which is too short, too wide, and

is inserted too far forward. In consequence of the shortness of the frenum, the mobility of the tongue and later the speech are interfered with. The frequency of this tongue-tie, due to a short frenum, is, however, much exaggerated by the laity and even by many physicians, and the tongue of a newborn child is often "loosened" when it is entirely unnecessary. I even go a step further and say that division of the restricting band is seldom really necessary.

The operation for tongue-tie consists in raising the tip of the tongue with the finger or some blunt instrument, and snipping the frenum thus put on the stretch with small curved scissors. The incision must not be too deep, for fear of cutting the ranine arteries which run under the mucous membrane of the tip of the tongue on each side of the frenum. For this reason the point of the scissors should be directed toward the floor of the mouth, and the frenum should be divided near the latter and not near the tip of the tongue. In case the artery is injured, the hæmorrhage may be arrested by ligation or by a deep suture.

In rare cases the frenum of the tongue in newborn children is too long, and the tongue, in consequence, falls back (so-called swallowing the tongue). According to Butlin, suffocation has repeatedly resulted from the sinking back or swallowing of the tongue (Petit, Fairbairn). Hennig has also called special attention to attacks of suffocation in children from this cause. In case such attacks of suffocation occur, the condition of the child's tongue or frenum should be carefully ascertained. We have already mentioned that, if proper precautions are not taken, suffocation may occur after excision of the middle piece of the lower jaw, as the tongue then sinks back in consequence of division of the genio-glossi muscles.

The treatment of the rare cases in which attacks of suffocation occur in newborn children from the sinking back of the tongue consists, according to Butlin, in introducing the finger between the palate and the tongue and pressing the latter forward. Nourishment should not be too abundant, and that from the breast is best.

Occasionally newborn children are found to have a cleft tongue (lingua bifida), in consequence of a longitudinal fissure of varying length. This cleft may be confined to the anterior part of the tongue, or, as rarely happens, it may extend back to a point near the root. According to Ahlfeld, cleft tongue is sometimes combined with facial clefts. As is known, a divided tongue is the rule in various animals—e. g., the seal, the raven, and snakes.

In extreme cases this deformity is overcome by freshening the edges and suturing them together.

Abnormal length of an otherwise healthy tongue is now and then observed. Butlin mentions two such cases of Fournier's. The tongue of a woman was so long that it constantly protruded between the teeth in folds. Another case is that of a girl who is said to have been able to touch her breast with her tongue. Speech is usually not impaired by abnormal length of the tongue, nor does other inconvenience attend it.

Hypertrophy of the tongue is more frequent, which is conditioned upon congenital tumours, especially lymphangeioma (see Tumours of the Tongue, § 60, page 382).

Sometimes hypertrophy of the tongue does not affect the entire organ but only the papillæ in the form of circumscribed or more diffuse warty growths. Butlin saw a case of congenital hypertrophy of this kind, in which the disease extended in the form of nodular growths over the whole papillary region of the dorsum of the tongue.

Congenital atrophy of the tongue is very rare, as well as acquired atrophy after injury or disease of the vessels and nerves. Hemiatrophy is observed somewhat oftener, especially as the result of diseases of the central nervous system (tumours, syphilis, softening of the brain, hæmorrhages in the vicinity of the nucleus of the hypoglossal nerve tabes, hemiplegia, progressive muscular atrophy, etc.). According to Ballet, hemiatrophy is a comparatively early symptom of tabes. Hemiatrophy from peripheral causes is much rarer, arising most frequently after injury or disease of the hypoglossal nerve. The half of the tongue affected is smaller and very much wrinkled. Hemiatrophy does not cause functional disturbance, and it is chiefly important as an aid in the diagnosis of disturbances of the central nervous system.

Congenital absence of the tongue has been recorded but once, according to Butlin, and then by Jussieu (1718). This was in a girl of fifteen, on the floor of whose mouth there was a small elevation in place of the tongue. In spite of entire absence of the tongue, speech was but little affected. The same may be true after total extirpation of the tongue. Chewing and swallowing, however, were somewhat impeded, and the patient was obliged to push her food backward in her mouth with her fingers.

Absence of the tongue probably depends upon absence of the first branchial arch and incomplete development of the second.

Stuttering.—The causes of stuttering are but imperfectly known as yet. It is to be regarded essentially as a neurosis, and, according to various authors, is to be explained as a disturbance in the co-ordination of the muscles of respiration, and especially of the muscles of the larynx. There is usually a hereditary weakly constitution, or, as Kussmaul expresses it, a "congenital irritable weakness of the apparatus for the co-ordination of syllables." In other cases the trouble is conditioned upon various diseases of the tongue, the naso-pharyngeal space, the ear, the larynx, etc. Kafemann has carefully investigated one hundred and fifty-one cases of stuttering. In forty-six per cent of these he found abnormal glandular growth in the naso-pharyngeal space, with or without hypertrophy of the tonsils. Ear trouble existed in twenty-seven per cent of the cases, though a causal connection is not to be hastily assumed. Sometimes nasal affections, etc., exist. According to Kafemann, it is most common in weakly (scrofulous) children. The treatment consists, above all, in combating the weak (scrofulous) constitution, and any local trouble that may exist—e. g., in the naso-pharyngeal space, the larynx, etc. ; in training the voice ; in strengthening the body ; and especially in trying by some toughening process (cold-water cure) to prevent catarrh, etc. Complete cure is in many cases secured by means of gymnastic training of the tongue, especially by teachers who devote themselves exclusively to dealing with stuttering, and make a sort of specialty of their art.

Operative treatment for stuttering has been properly abandoned. Dieffenbach repeatedly tried incisions at the root of the tongue, simple incision, for example, with or without preservation of the mucous membrane, also division of the genio-glossi muscles at their middle after previous division of the frenum, or at their insertion on the lower jaw from within the mouth or the outside. Division of these muscles near the body of the lower jaw was usually accomplished from within the mouth. This operation has now, however, merely historical worth.

§ 58. **Injuries of the Tongue.**—Injuries or wounds of the tongue occur most frequently from its being pinched between the teeth, in epileptic attacks, for instance, or in case of a fall or blow upon the chin when the tongue is protruded. Injury may also be caused by sharp tooth-edges, fish bones, bits of bone, etc. Stabs and incised and gunshot wounds are much less frequent. The hæmorrhage and subsequent swelling in connection with wounds of the tongue may be considerable, especially after gunshot wounds. In the latter, balls sometimes enter the substance of the tongue, and in rare cases have remained there for years. Bits of the teeth and fragments of bone may also be driven into the substance of the tongue in gunshot wounds, and may heal up there. In general, wounds of the tongue tend to heal rapidly, especially incised wounds that have been sutured, and even badly contused flap wounds with a small, thin pedicle.

The treatment of wounds of the tongue follows the general rules. Above all, the mouth should be kept constantly clean with antiseptic solutions. If there is bleeding, it is usually arrested by the deep stitches that are taken in the wound. When the wound is in the posterior portion of the tongue, the arrest of the hæmorrhage and the suturing may be more difficult, and it may be necessary in such cases to resort to anæsthesia, and to hold the mouth wide open by means of a mouth gag. The tongue is then drawn forward and out of the mouth by means of a loop of silk passed through it. The wound can then be well seen and treated. In case of deep stab wounds, with injury to an artery, the wound may be enlarged and the wounded artery tied. In case of deep wounds in the posterior part of the tongue, the lingual artery has been tied above the hyoid bone from the outside, and even the external or common carotid have been ligated.

Wounds of the tongue are always sutured with curved needles and needle holder, silk or catgut being used. Flap wounds should be sutured with special care. In case of gunshot wounds, attention must be paid to the removal of the ball or other foreign bodies, should they be driven into the substance of the tongue. If the swelling is marked, multiple scarifications are advantageous. Tracheotomy is seldom necessary.

The after-treatment consists in the use of antiseptic mouth washes and in giving soft or liquid food. In case there is considerable swelling the patient should swallow pieces of ice. Iodoform is excellent, especially for contused wounds. It is applied with a small swab or an insufflator. Stings and bites of insects, especially bees or wasps, may lead to very painful inflammatory swelling of the tongue, and cause it to protrude from the mouth. I have repeatedly seen stings inflicted by wasps or bees that had been concealed in fruit. Bites from poisonous snakes are very rare. The inflammatory swelling resulting from this class of injuries may occasion alarming dyspnœa. Stings from insects usually heal rapidly.

The treatment for the stings of insects—e. g., bees and wasps—consists in washing the mouth with a weak solution of ammonia and in the use of pieces of ice to swallow. In case of considerable swelling, multiple scarifications with a pointed knife are to be recommended.

Burns of the Tongue.—Slight burns of the tongue are very frequent in consequence of taking too hot food into the mouth. Severer burns are caused by chemical materials, such as mineral acids, caustic alkalies, and the like. Scalding of the tongue very often attends the attempts of children to drink fluids that are too hot or boiling. When the burn is severe, vesicles form upon the tongue just as upon the skin. Burns of the tongue heal, as a rule, quickly. Those at the base of the tongue and the entrance of the larynx are the most unfavourable, since here, owing to the swelling, disturbances in respiration may arise in consequence of œdema of the glottis.

The treatment of burns consists, above all, in giving small pieces of ice to relieve the pain, which, as a rule, soon subsides, and in the use of antiseptic mouth washes, iodoform, etc.

Foreign Bodies in the Tongue.—Foreign bodies sometimes heal up in the tongue without reaction. Butlin mentions a case of Manget's in which a ball remained six years in the tongue. The patient stuttered during this time, but ceased to do so after the ball was removed. Sometimes the presence of the foreign body is betrayed by the formation of a hard, circumscribed tumour, or by secondary hæmorrhage, or by the formation of a fistula. I removed in one case what was supposed to be a carcinoma, and found an embedded silk suture which the former surgeon had not removed after an injury to the tip of the tongue that had occurred a year before. Boyer operated upon a soldier with a hard tumour of the tongue, and found at the end of a small sinus a bullet, which he removed by incision. Sometimes after the removal of a foreign body severe hæmorrhage has been seen to occur from a wound in an artery of the tongue which had been closed by the foreign body. The latter is often cast off spontaneously by the formation of an abscess. It may also migrate and appear at some other place—on the neck, for instance.

§ 59. **Inflammation and other Diseases of the Tongue.**—Acute inflammation of the tongue (acute glossitis) is either more or less localized—in one half of the tongue, for example (hemiglossitis), or extends over the entire organ. The causes of acute glossitis are injuries, especially stab and gunshot wounds, stings of insects (bees, wasps, etc.), burns, and stomatitis arising in the course of febrile diseases, such as typhoid fever, the acute exanthemata, or severe tonsillitis. I saw severe acute glossitis in a butcher which was the result of infection from anthrax. The inflammation frequently starts from ulcers of the tongue following mercurial stomatitis, for instance, or it may arise from the extension of a neighbouring inflammation, such as erysipelas of the skin or mucous membrane.

From a clinical point of view, we may distinguish essentially two forms of acute glossitis: (1) acute parenchymatous glossitis, which does not go on to suppuration, and (2) a severe diffuse suppurative phlegmon of the tongue and floor of the mouth, resulting from septic infection of a wound of the tongue or inside of the mouth.

Acute glossitis runs usually a very rapid course, and the swelling increases very quickly. The tongue is made stiff by the swelling, so that talking and eating become more or less difficult. Within twenty-four hours after the sting of a bee or wasp, for example, the tongue may become two or three times its normal size, and protrude so as to lie in front of the teeth. The pain is usually severe, the tongue dry and more or less coated, and the secretion of mucus profuse. The interference with breathing may become so great as to necessitate tracheotomy. The temperature often reaches 39° or 40° C. (102° to 104° F.).

The further course of acute glossitis is usually favourable. The swelling wholly disappears, as a rule, in from two to five days, though it sometimes continues to a certain degree for a longer time. In other cases a circumscribed abscess forms, and, more rarely, severe diffuse suppuration and death from septicæmia or pneumonia. Gangrene of a portion of the tongue is seldom observed.

Chronic encapsulated abscesses are sometimes left in the tongue, which, in consequence of the reactive induration around them, are easily mistaken for carcinoma.

The prognosis of acute glossitis is generally good, as the mild cases are by far the more numerous.

The therapy in mild cases consists in the antiseptic treatment of any wound that may be present, careful disinfection of the mouth with suitable washes (chlorate of potash, boric acid, ratanhia, etc.), and giving small pieces of ice and liquid food. Cathartics are also decidedly

beneficial. In severer cases attended with marked swelling, multiple scarifications, or a not too deep longitudinal incision upon each half of the tongue, have a surprisingly beneficial effect. The patient is much relieved and the hæmorrhage is usually moderate. Particularly in case of diffuse phlegmonous inflammation the incision should be made at once, without waiting for suppuration. If there is an abscess at the base of the tongue, the incision is best made with a long and somewhat curved bistoury whose edge is covered with adhesive plaster nearly to the point, so as to avoid injury to the adjacent parts. In case of infiltration or fluctuation under the chin in front of the hyoid bone, an incision is made through the skin in the middle line and some long, blunt instrument is then inserted until the pus focus is reached, which is afterward drained externally. In gangrene of the tongue, iodoform and frequent cleansing of the mouth with disinfecting washes are to be recommended. If the swelling of the tongue and entrance to the larynx (œdema of the glottis) is such as to cause danger of suffocation, tracheotomy is indicated.

Among chronic inflammations of the tongue, tuberculosis, syphilis, and actinomycosis especially interest us.

Tuberculosis of the Tongue occurs most frequently in persons of middle age already suffering from phthisis. It is much less common in persons who are otherwise healthy, and in such cases tuberculosis of other organs soon develops, as a rule. Primary tuberculosis of the tongue is, at all events, very rare. The disease is almost always secondary, following tuberculosis of the larynx or the lungs.

Tuberculosis of the tongue appears now in the form of torpid or fungous ulcers, and again as deep-reaching, cheesy nodules, which soften in the centre. Tubercular ulcers of the tongue which are surrounded by an indurated area may sometimes be confounded with carcinoma, while the tubercular nodules resemble gummata. The local behaviour, the entire clinical course of the disease, and, above all, the detection under the microscope of tubercle bacilli in small excised portions of tissue, insure the diagnosis. It is characteristic of tubercular ulcers to be surrounded by small nodules, mostly miliary in size. The ulcers themselves have usually a cheesy base, the granulations are pale and flabby, and the edges are usually soft, as compared with carcinoma. Cases sometimes occur in which the entire surface of the tongue is covered with confluent tubercular ulcers from the size of the head of a pin to that of a pea, between which miliary tubercles are to be seen in great numbers. Tubercular ulcers are usually, in the later stages, very painful, so that when touched with the softest food extreme pain is felt. In the nodular form of the disease a small, painless indu-

ration forms at first beneath the mucous membrane of the mouth, most frequently that of the tongue, which gradually enlarges and then interferes with the mobility of the tongue. The tumours, which become as large as hazelnuts or even larger, are at first hard, the mucous membrane that covers them being smooth. The neighbouring lymph glands are seldom swollen. The nodules break down later from cheesy degeneration and finally suppurate.

The prognosis of secondary tuberculosis of the tongue is almost as unfavourable as that of carcinoma. In the great majority of cases the patients die in from one to two years, or after a few months, it may be, from tuberculosis of the larynx, the lungs, or the digestive organs. In rare cases complete recovery, even in persons with marked hereditary tendencies, has been observed. According to Schliferowitsch, who collected eighty-eight cases of tuberculosis of the mouth, the prognosis of primary tuberculosis is far better, and the probability of recovery from the nodular form of the disease is greater than from the ulcerative form.

The treatment of tuberculosis of the tongue should be of an operative nature, the tubercular areas being radically removed as soon as possible by excision or by Paquelin's thermo-cautery or the galvano-cautery, as in carcinoma. In suitable cases, the sharp spoon may be energetically used, and the parts then thoroughly cauterized with the thermo-cautery. In inoperable cases everything should be avoided that tends to irritate the ulcer or the diseased area. Hence, sharp edges of decayed teeth should be removed. Nourishment should be soft but strengthening. The application of caustic substances is to be avoided. Washes of borax, chlorate of potash, alum, tannin, or the application of iodoform with a little morphine three or four times a day, are of service locally. If the pain is very severe and the ulcer can not be removed by an operation (excision, Paquelin's thermo-cautery, galvano-cautery), the question arises whether the lingual nerve should not be divided (see page 252). It is known that great relief can be secured in this way for patients suffering from inoperable carcinoma of the tongue.

Syphilis of the Tongue.—Syphilis shows itself upon the tongue under a variety of forms.

I. In rare cases, primary syphilitic infection is observed in the form of the syphilitic primary sclerosis or hard chancre.

II. Much more frequent are the secondary and tertiary manifestations in consequence of the systemic infection, especially mucous patches, secondary syphilitic ulcers, and gummata.

Mucous patches appear at any stage of secondary syphilis on different parts of the tongue, especially on the edges, the dorsum, and the tip, and are accompanied by other manifestations of the disease. Similar patches or ulcers are usually found on the lips, at the corners of the

mouth, on the mucous membrane of the cheeks, on the soft palate, and on the tonsils. They are, as a rule, slightly elevated, smooth or uneven, grayish-white formations, round or oval in form. Under the grayish-white covering, which can usually be removed, there is a red, elevated surface. Sometimes cauliflower-like growths are observed which resemble a papillary carcinoma. Fissures of the tongue—that is, linear or more stellate ulcers—often result from mucous patches.

Syphilitic ulcers of the tongue are very common. They originate partly from macular and papular syphilides of the mucous membrane and mucous patches, but most commonly from the breaking down of gummata. The characteristics of syphilitic ulcers are their slightly inflamed sharp edges, their circular form, their multiple occurrence, and their combination with other syphilitic manifestations, particularly in other parts of the mouth (palate, lips), and on the skin.

From ulcers which are at first superficial there often develop, especially in the later stages of syphilis, deep, punched-out ulcers covered with sloughs. They sometimes increase rapidly in size, so that a large area of the tongue is affected. After the healing of these larger and deeper ulcers, thick, distorted cicatrices form, so that a syphilitic tongue of this sort is crossed by disfiguring furrows and fissures.

Gummata sometimes appear in considerable numbers on the tongue in severe cases of syphilis, and in various stages of breaking down and ulceration. They arise most commonly in the submucosa. Sometimes the entire process remains submucous—that is, the nodules do not break through externally, but are absorbed, and in their place there arises a circumscribed or more diffuse growth of fibrous tissue causing a nodular condition of the tongue.

Fournier described a sclerotic glossitis which appears sometimes independently and sometimes as a later condition following syphilitic ulcers and gummata. In this sclerotic glossitis, which may be superficial or more deeply situated, we have to do with a cellular infiltration which changes into firm fibrous connective tissue. In this way diffuse indurated areas or circumscribed nodules arise, with peculiar distortion of the tongue, especially when areas of some size are affected. The course of this form of syphilitic glossitis is very chronic.

The treatment of syphilis of the tongue is partly local and partly constitutional by the use of mercury in inunctions or hypodermically. In the later stages the iodide of potassium, in not too small doses, is the best remedy. (For the treatment of syphilis, see Principles of Surgery, § 84.)

As regards the local treatment, the following may be remarked: In case of chancre, speedy destruction of the focus of infection by

excision or by the galvano-cautery is to be recommended. Later syphilitic ulcers of the tongue are treated in accordance with general rules. The application of two-per-cent chromic acid (once or twice a day), boroglyceride, tannate of glycerin, and particularly of iodoform with morphine, if the pain is severe, is very serviceable. The ulcers are, moreover, cauterized from time to time with the nitrate-of-silver stick, and attention is paid to carefully cleansing the mouth with washes (borax, chlorate of potash, etc.). Smoking should be strictly prohibited.

In severe secondary or tertiary syphilis of the tongue with deep ulcers or broken-down gummata, operation should likewise be resorted to. During anæsthesia or under cocaine the tongue is drawn forward by means of a loop of silk passed through its centre, and the affected part is thoroughly scraped and afterward treated with the thermo-cautery or galvano-cautery. For the after-treatment, iodoform is to be recommended. In case of sclerotic glossitis the iodide of potassium is given in large doses.

Actinomycosis of the tongue is not very rare. Of twenty-one cases treated in Albert's clinic from 1882 to 1888, four affected the tongue. For a description of actinomycosis the reader is referred to Principles of Surgery, § 86.

Inflammation of the Lingual Tonsil.—In chronic pharyngitis, hypertrophy of the tonsils, and laryngitis, a hypertrophy of the tissue analogous to the tonsils at the base of the tongue (the lingual tonsil) sometimes takes place. One sees, by use of the laryngeal mirror, in front and to the side of the middle glosso-epiglottic ligament, nodules with clefts of a pink or grayish-red colour, from the size of a pea to that of a bean. In every case of chronic pharyngitis these should be looked for. They are best removed by the galvano-cautery (Baron, Schäde, Rosenberg).

The acute inflammations of the lingual tonsil and its neighbourhood (tonsilitis lingualis acuta, peritonsilitis lingualis phlegmonosa) resemble the acute inflammations of the tonsils themselves, and lead to inflammation and œdema of the glottis and acute glossitis. The inflammation but seldom spreads to the interior of the larynx. The lingual tonsil forms an important point of entrance for infection in the production of inflammation of the epiglottis and acute glossitis. The inflammatory process is usually superficial, and often terminates in abscess formation.

Nervous Affections of the Tongue.—Under nervous affections of the tongue are to be mentioned disturbances of motion (spasm and paralysis), disturbances of sensation (neuralgia and anæsthesia), and disturbances of taste.

Spasm of the Tongue.—Spasm of the hypoglossal nerve, as all authors agree, seldom exists alone, but is much more frequently a symptom of various systemic nervous disturbances, including those following injuries of the central nervous system, such as concussion and contusion of the brain, and in

hysteria, chorea, epilepsy, eclampsia, progressive muscular atrophy, and bulbar paralysis. It is due partly to peripheral and partly to central disturbances. Reflex spasm of the tongue has been observed in connection with diseases of the teeth and gums. One of the most common forms of spasm of the hypoglossal nerve shows itself in involuntary attacks of protruding the tongue. Butlin mentions a case of Winograd's, that of a girl of nine years, whose tongue was pushed out of the mouth at comparatively regular intervals, and kept there from eight to fifteen seconds at a time. If this protrusion is prevented by pressing the teeth together, the spasm sometimes goes on inside the mouth and the tongue may be heard striking against the teeth (Berger). The spasm may occur altogether independently without any co-operation of the patient, or it may be induced by definite movements, either made or intended, such as the attempt to speak or to eat (Vallin). Articulation spasm resembles writer's cramp and ordinary stuttering (aphonia spastica), which, according to Butlin, is mainly caused by imperfect co-ordination of the muscles of respiration and those of the larynx (see also page 370).

The prognosis is usually good.

The treatment is directed, above all, toward the cause. Aside from this, the use of electricity in the form of the galvanic current is to be recommended and the administration of quinine, bromide of potassium, iron, belladonna, strengthening diet, etc. Sea voyages also are particularly beneficial.

For articulation spasm Butlin and others recommend that patients should frequently speak and read aloud in order to restore gradually the co-ordination of the different muscles.

Paralysis of the tongue, unilateral or bilateral, is almost always due to injuries or diseases of the central nervous system, seldom to peripheral disturbances, such as injury to the hypoglossal nerve or pressure from a tumour. For a more exact description of the motor and sensory disturbances of the tongue, and particularly the disturbances of taste, the reader is referred to text-books on nervous diseases.

Neuralgia which confines itself to the lingual nerve is very rare. The main trunk from which the lingual nerve branches—viz., the inferior maxillary—is usually affected. The cure of neuralgia of the tongue is usually difficult, and it is often hard to be sure of its causes, aside from cases in which it is due to decayed teeth, sharp tooth-edges, "taking cold," or operations upon the tongue.

The same rules apply to the treatment of neuralgia of the lingual nerve as to the other branches of the fifth nerve. For this the reader is referred to § 34, page 241. More exact information is also given there for the best way to expose the lingual nerve in case it is thought best to stretch or divide it.

Other Diseases of the Tongue.—The tongue is the seat of certain diseases that are analogous to those of the skin.

Herpes of the tongue—that is, groups of vesicles or pustules—is observed especially in cases of disturbances of digestion, particularly in drunkards. The vesicles are chiefly on the tip or the edges of the tongue.

Treatment consists in remedying the digestive disturbances, avoiding the use of alcohol, and in local application of subnitrate of bismuth, borax, and solutions of tannin or alum.

Pemphigus of the tongue—that is, the formation of large vesicles upon the tongue and the mucous membrane of the checks, filled with a yellowish sero-purulent material—is very rare. Butlin mentions a case of Dickson's in which pemphigus of the tongue and then general pemphigus of the skin appeared with fever, the patient being a woman who had become exhausted in taking care of a patient.

Lichen of the tongue is described by Butlin as a collection of white spots and streaks which are at first punctate and afterward larger and confluent. Lichen of the skin is always present, according to Butlin. Arsenic has been especially recommended in its treatment.

Leucoplakia of the tongue is a change of its mucous membrane into a thin, bluish-white or pearl-gray covering which can not be separated from the underlying tissue without causing bleeding and a loss of substance. The extent of leucoplakia is very variable. It causes, as a rule, no real inconvenience. There are slight subjective sensations when in the later stages the white coating becomes thick and firm or becomes separated from the subjacent tissue. Opinion differs greatly as to the nature of leucoplakia of the tongue, many believing that it is analogous to psoriasis of the skin. It is mainly a chronic inflammation of the mucous membrane (Nedopil). Its course is very chronic and recovery very rare. It frequently changes into epithelioma (Butlin).

Its treatment consists in discarding smoking and chewing, in avoiding irritating food and that which is very sweet or very sour, in removing any sharp tooth-edges that may exist, etc. In case of syphilis the treatment should be antisyphilitic. All strongly irritating local applications, particularly caustics, are to be avoided. Painting it with alcohol and glycerin, equal parts, one- to two-per-cent chromic acid, or five- to ten-per-cent papayotin (Schwimmer), and gargling with alum, borax, bicarbonate of soda, etc., are most to be recommended. The galvano-cautery is particularly effective. Circumscribed spots should be excised through sound tissue.

Ichthyosis of the tongue is described by Hulke as a, for the most part, circumscribed, hard, warty, sometimes horny hypertrophy of the papillæ of the dorsum of the tongue, resulting from chronic superficial glossitis. It is regarded by most authors, including Butlin, as a variety of leucoplakia or psoriasis of the tongue, from which it is said not to be distinguishable histologically. The extent of surface of the tongue involved is very variable. In proper cases excision or the use of the galvano-cautery is to be recommended as the best treatment.

By nigrities linguæ (black tongue—Vernet, Schech, Ciaglinski, and others) is understood the formation of black or dark-brown spots on the tongue as the result of various causes, such as the presence and growth of mould fungi, hypertrophy, cornification, and subsequent degeneration of the epithelium with pigmentation, moreover, in Addison's disease. The black tongue due to the growth of mould fungi is usually a more acute disease, while in other cases its process is more chronic (see also Hairy Tongue).

Smokers' patches, so called, are, according to Butlin, dark-red or brownish-red, bluish-white or pearl-gray, circumscribed spots, especially on the anterior

part of the dorsum of the tongue, conditioned upon a change in the epithelium caused by smoking. They also, like leucoplakia, sometimes change into epithelioma. Their treatment consists, above all, in discarding smoking and the use of alcohol, the local treatment being the same as for leucoplakia.

By wandering rash (annulus migrans, tinea tonsurans) is understood a very rare disease of the tongue which occurs especially in weakly children who are inmates of children's hospitals or homes for foundlings. From red spots which are at first as large as a pea there gradually develop circular or oval rings with yellowish margins. From the presence of many such rings we have the so-called "map" tongue. According to Vanlair, we have to do with a chronic papillitis. Syphilis, parasites, nervous influences, and teething are assigned as causes of this innocent chronic trouble, which, as a rule, causes simply a little itching and a flow of saliva. Its treatment consists in the use of astringents, such as one- to two-per-cent chromic acid, and, above all, in good nourishment.

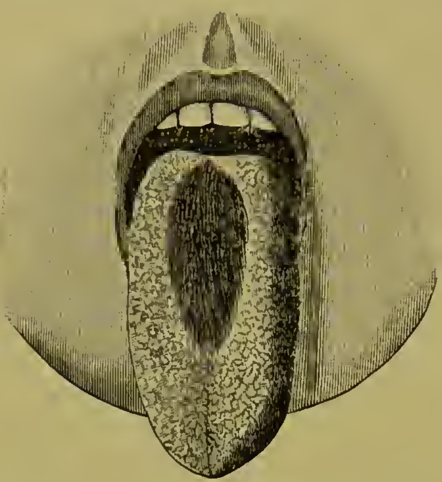


Fig. 225.—Black "hairy tongue" in a girl of fourteen.

In many forms of superficial glossitis there is a striking smoothness of the tongue resulting from a degeneration of the papillæ. Painful excoriations and superficial ulceration also occur not infrequently. Smoking, acrid or spiced food, and strong wine are the most potent causes of this chronic inflammation of the submucosa with atrophy of the mucous membrane. When ulceration has thus arisen, the above injurious influences must be avoided. In addition, local application is made of borax or one-per-cent chromic acid and the mouth gargled with chlorate of potash.

Hairy tongue is the name given to the formation of long, hairlike processes over the points of the papillæ of the tongue, in consequence of hyperplasia of the epithelium. The tongue is usually heavily coated. Rydygier observed a black velvetlike tongue (Fig. 225) whose dark coating consisted of epithelial cells and fungus-mycelia above the hypertrophied filiform papillæ. The black coating could be washed away with a solution of chlorate of potash. W. Roth recommends painting with ten-per-cent salicylic acid in alcohol or ten-per-cent alcoholic bichloride after the tongue has been scraped.

We have already spoken of the development of excoriations, fissures, and ulcers of the tongue. We saw that traumatisms of the greatest variety, and particularly the sharp edges of carious teeth, disturbances of digestion, the several forms of stomatitis, tuberculosis, syphilis, etc., produce ulceration to a greater or less degree. The treatment has been given in connection with stomatitis, thrush, tuberculosis, and syphilis of the tongue.

Indentations of the edges of the tongue occur in older people and are caused mainly by the teeth. Butlin has given a representation of a very characteristic and extreme case in his book on diseases of the tongue.

Folds and furrows of the tongue are most frequently seen in drunkards and in connection with syphilis (see page 376).

In leprosy there are small pale tubercles and ulcerations of the tongue of which the diagnosis is made possible by manifestations of leprosy in other parts of the body and by microscopic demonstration of the presence of lepra-bacilli (see Principles of Surgery, § 85).

Actinomycosis of the tongue has been repeatedly described. In a case reported by Hacker a hard nodule the size of a hemp seed was found on the tip of the tongue, from which, when punctured, the characteristic granules were obtained (see Principles of Surgery, § 86, Actinomycosis).

Among animal parasites of the tongue, Butlin mentions the rare occurrence of the trichina, and in one case that of the dracunculus (*Filaria medinensis*, guinea worm). The worm had probably made its way under the tongue through one of the salivary ducts or through the duct of the Blandin-Nuhn glands and caused a painful tumour at the tip of the tongue in the vicinity of the frenum.

§ 60. **Tumours of the Tongue.**—Benign tumours of the tongue are comparatively rare, the malignant ones, especially carcinoma, being most frequent. The differential diagnosis between benign and malignant tumours is more difficult at the base of the tongue, because ulceration may occur in the benign forms in consequence of mechanical and chemical irritation. The lingual tonsil is of special importance in connection with the formation of tumours at the base of the tongue (see page 377).

Of the non-malignant tumours, the lipoma has been observed in rare cases on the dorsum or edge of the tongue, for example (Fig. 226, after Rydygier), or on the floor of the mouth beneath the tongue. The lipoma of the dorsum of the tongue originates, probably, in the submucosa or in the intramuscular tissue, and is either found as a more or less pedunculated tumour on the dorsum of the tongue, or is situated within the substance of the same.

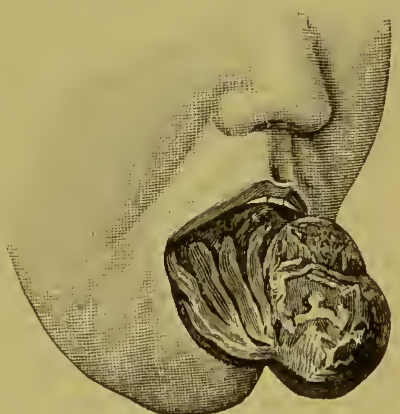


Fig. 226.—Lipoma of the tongue in a woman twenty-nine years old.

The extirpation of a pedunculated lipoma is accomplished, after painting the area with a five- to ten-per-cent solution of cocaine, simply by use of the scissors or galvano-cautery. Hæmorrhage from the pedicle is best checked by the galvano-cautery. The submucous encapsulated lipoma of the substance of the tongue is also easily removed through an incision. Fibroma is somewhat more common than lipoma. It is found single or multiple, and may have a pedicle or a broad base. Occasionally a deep-seated fibroma is found in the substance of the tongue, which can very easily be mistaken for a cyst. The operative removal of a fibroma is essentially the same as that of a lipoma, which has been briefly described.

Sedgwick saw a case of keloid of the tongue.

In rare cases chondroma and even osteoma of the tongue have been observed. Weber, Arnold, Bastien, and others have described chondroma of the tongue. Chondroma and osteoma always arise from strayed embryonic cartilage cells.

Angeiomata of the tongue are partly capillary and partly venous or arterial. It is best to distinguish (1) the simple angeioma (telangeiectasis, nævus vasculosus, plexiform angeioma), consisting of enlarged and newly formed capillaries, arteries, and veins. We include here also the cirsoid aneurism, a pulsating angeioma which arises from dilatation and proliferation of capillaries and small arteries. (2) The cavernous angeioma (tumor cavernosus), which consists of cavities lined with endothelium and filled with fluid or coagulated blood.

FIG. 227.—Macroglossia (lymphangeioma) in a girl of twenty (Clinic at Göttingen).

Varicose aneurism of the veins corresponds to the cirsoid aneurism of the arteries.

Between these capillary, arterial, and venous angeiomata there are numerous transition forms, and, as a rule, we have to do partly with capillary and venous or with capillary and arterial angeiomata. They form, accordingly, sometimes bluish and sometimes light-red characteristic tumours, which seldom exceed a walnut in size. Congenital angeiomata of the tongue may wholly disappear spontaneously or may remain stationary, or, again, may rapidly develop into large tumours. Angeiomata are situated either on the surface of the tongue or in its substance. Hæmorrhage is always the chief danger from the superficial angeiomata.

Still more frequent than tumours of the blood-vessels are the analogous lymphatic formations or lymphangeiomata. Most cases of so-called congenital macroglossia (prolapsus linguæ) are, as Weigner in particular has shown, due to lymphangeioma (see Fig. 227). Lymphangeiomata consist essentially of dilated and hypertrophied lymphatics which may change, like angeiomata, into cavernous and pronounced cystic formations. Accordingly, we distinguish, (1) simple lymphangeioma, (2) cavernous lymphangeioma, (3) cystic lymphangeioma.

Lymphangeiectasis and angeioma are sometimes found combined in macroglossia, and marked enlargements of the tongue then occur. W. Busch has illustrated such a case, in which there was a degeneration of the tongue, partly cavernous and partly of the nature of lymphangeiectasis (see Fig. 228). Macroglossia is sometimes caused by muscular hypertrophy.

The treatment of angeioma and lymphangeioma is essentially the same. The application of Paquelin's thermo-cautery or the galvano-cautery is most to be recommended. In case of large tumours this treatment may have to be repeated at different sittings. Circumscribed more or less pedunculated angeiomata may be excised with or without previous ligation of the lingual artery (see § 62, page 396).

Primary sarcoma of the tongue is very rare. Albert, Jacobi, Godlee, Targett, and others have described cases of it. The round-celled form is the most frequent, the spindle-celled form less so. In one case described by Albert extensive metastases occurred. Berg (Stockholm) and Santesson observed a plexiform sarcoma of the tongue. The sarcoma is generally situated deep in the substance of the tongue, and may be mistaken for an abscess, a gumma, or actinomycosis. Its duration varies from a few months to from three to twelve years.

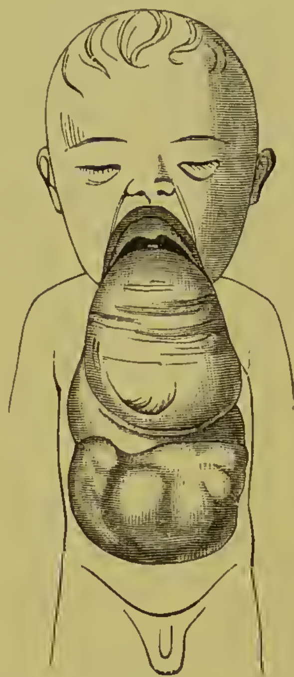


Fig. 228.—Lymphangeioma and cavernoma of the tongue.

Papillomata resulting from hyperplasia of the epithelial covering and of the papillæ are seen most frequently on the dorsum of the tongue. The papilloma is properly a mixed tumour, arising from a new formation of connective tissue and epithelium. Hard and soft papillomata are distinguished. The hard consist largely of epithelial cells, while the soft are characterized by a more vascular stroma, and fewer epithelial cells. To the latter belong certain cauliflower growths and the so-called pointed condylomata. These non-malignant papillary growths must not be confounded with syphilitic mucous patches or with papillary carcinomata. Carcinomata of the tongue also arise sometimes from what are at first non-malignant papillary growths of this sort. It is characteristic of carcinoma that the base of the tumour is hard and infiltrated, while that of the papilloma is soft. Carcinoma of the tongue is, moreover, seldom observed in persons less than forty years of age. Papilloma, on the other hand, occurs in younger people also.

Fig. 229.—Tumour of the tongue composed of thyroid tissue in a woman who died of old age (Kast and Rumpel).

The removal of a papilloma is accomplished with scissors or with the knife, and the hæmorrhage is stopped by cauterization of the stump.

Adenomata of the tongue are rare. They sometimes form polypus-like growths, and sometimes are deeply seated in the substance of the tongue. Acinous as well as tubular adenomata have been observed. The deeper form develops sometimes from the mucous glands near the tip of the tongue.

Goitre of the tongue is of special interest. It occasionally arises from strayed embryonic cells of the thyroid gland situated in the tongue or floor of the mouth (Fig. 229). Wölfler, Kast, R. Wolf, Bernays, Warren, and others have described cases of this kind.

Cysts of the tongue, aside from the above-

described lymph and blood cysts, are usually retention cysts of the mucous glands, and seldom exceed the size of a hazelnut. They form tense, fluctuating tumours, with mucous or gelatinous contents. They project, as a rule, above the surface of the dorsum or edges of the tongue, seldom lying deeper in the tissue. Cysts of the base of the tongue arise, according to Rosenberg, either from the fœtal glands, from the so-called ductus excretorius linguæ, which, extending from the glosso-epiglottic ligament to the foramen cæcum, thirty-four millimetres long, often receives numerous excretory glandular ducts, or, finally, from branchial fistulæ. Dermoids arise particularly from the duct above mentioned and from branchial fistulæ.

Parasitic cysts of the tongue (cysticercus cellulosæ and echinococcus) are very rare.

The treatment of cysts consists in incision with the removal of as much as possible of their wall after previously painting the part of the tongue involved with a five- to ten-per-cent solution of cocaine. The rest of the wall may be destroyed as completely as possible with the cautery.

Ranula.—The cyst which is most important in a practical way is the ranula or "little-frog cyst," situated under the tongue (Fig. 230). The etiology of ranula was formerly wholly in doubt. Recklinghausen was the first to show, by careful anatomical investigation, that it most frequently arises from cystic dilatation of a main excretory duct of the mucous glands which lie at the tip of the tongue. The duct is obstructed, it may be by inflammatory processes in its interior or in its vicinity, and then, by damming back of the secretion of the gland, a characteristic spherical or more oval cyst develops under the tongue to one side or on both sides of the frenum. The ranula contains a thick tenacious mucous fluid.

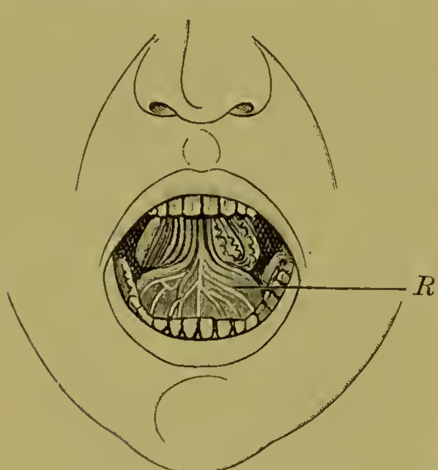


Fig. 230.—Ranula.

Aside from the typical ranula, which is to be regarded as a retention cyst of the mucous glands, there are other analogous cystic formations under the tongue which are likewise to be classed with the ranula, and which cause the same manifestations. Here belong the occasional retention cysts of the excretory duct of the submaxillary gland (Wharton's duct), resulting from injury to the duct, from inflammation, or from a concretion (see § 84). Sublingual cysts may arise in the same way from obstruction of the excretory ducts of the sublingual gland, the duct of Bartholin, or the ducts of Rivini.

Dermoid cysts also (see below), and branchiogenic cysts, may resemble ranula. The assertion of Fleischmann, that the ranula also

arises from a mucous bursa on the surface of the genio-glossus muscle, is, according to Recklinghausen, incorrect.

Special care must be exercised in operating upon ranula, as otherwise recurrence takes place. Simple incision is never sufficient. Complete extirpation of the thin wall of the cyst is usually impossible. The best method is to apply cocaine, seize the anterior wall of the cyst with a mouse-tooth forceps, remove it as completely as possible with small curved scissors, and then unite the edges of what remains of the wall with the mucous membrane of the mouth by catgut sutures. I then very lightly cauterize the posterior wall, especially in the direction of the mucous glands, toward the tip of the tongue. The cavity which is thus left very soon disappears. In this method recurrence scarcely ever occurs, though it is sometimes necessary to break up too early adhesions with a probe, and make a light application of nitrate-of-silver stick. The further after-treatment consists in the use of an antiseptic mouth wash. Felizet recommends the extirpation of ranula in the following manner: He injects about twelve drops of a five-per-cent solution of cocaine into the submucosa, and eight to ten cubic centimetres of boric-acid solution around the cyst, so that the latter is surrounded by an artificial œdema; he then incises the mucous membrane that covers it, empties its contents by incision, introduces a small sponge, and closes the opening with a clamp. The almost solid tumour is now easily shelled out of the œdematous tissue.

Dermoid cysts are sometimes found in the floor of the mouth, mostly in the median line between the genio-hyoid and genio-glossus muscles above the mylo-hyoid, and are adherent either to the hyoid bone or the lower jaw. Sometimes, as an exception, the cysts lie to one side. They are removed either from the outside or from the mouth. Instead of their extirpation, a broad opening of the cysts with the thermo-cautery and energetic cauterization with chloride of zinc may be undertaken.

Carcinoma of the Tongue.—Carcinoma of the tongue is chiefly a disease of persons well advanced in age. It appears especially on the anterior part of the tongue and on its sides, more rarely on its posterior half. Carcinoma of the tongue arises most frequently from the pavement epithelium, and less often from the glandular epithelium. Bottini, on the other hand, observed just the opposite; among one hundred cases the carcinoma began eighty-four times in the glandular epithelium and sixteen times in the pavement epithelium. The tumour was usually lateral. Central carcinomata of the tongue are rare, and those of the tip of the tongue still rarer.

This disease generally attacks men from forty to sixty years of age. According to Barker's statistics, among two hundred and ninety-three patients with carcinoma of the tongue, but forty-six were females; of seventy-six patients tabulated by Pennell, sixty-seven were males and but nine females. This comparatively great frequency of the disease in males is explained by the circumstance that various predisposing causes are at work in the case of men which are not present in the same degree in the other sex. As most important among these may be mentioned smoking, chewing, and the use of alcohol. From these injurious influences there arises first a chronic, superficial glossitis, which may then gradually pass into carcinoma. In this way is to be explained the development of carcinoma from leucoplakia, from the greatest variety of chronic ulcerations, and especially from irritation caused by sharp edges of carious teeth. Esmarch has seen typical carcinoma of the mucous membrane of the mouth in the neighbourhood of the lower wisdom tooth, even in persons in the twenties, the result of chewing tobacco. Irritation of the surface of the tongue in the greatest variety of ways is, at all events, a very important predisposing cause of carcinoma formation. It is hence very unwise to treat chronic ulceration too long or too frequently with caustics. Carcinoma of the tongue not infrequently develops from benign epithelial growths and from cicatrices.

The beginning of carcinoma of the tongue is very variable. If it develops from an ulcer or from a papilloma, the cancerous formation usually begins with hardening of the ulceration or the papilloma. In other cases it begins as a small nodule or vesicle, as a diffuse induration, as a chronic glossitis with hypertrophy and fissure formation, or with destruction of the papillæ, as leucoplakia, or as a fissure, etc.

Fig. 231.—Papillary carcinoma of the tongue and soft palate.

The fully developed carcinoma of the tongue is either a deep sloughing ulcer, with elevated, nodular, everted edges and indurated surroundings, or a warty, papillary growth with clefts and furrows (papillary carcinoma, Fig. 231), or, finally, the part of the tongue affected changes into an indurated tissue without ulceration, as in scirrhus, for example. The ulcerative form is present in by far the larger number of cases. Other manifestations of carcinoma of the tongue are swelling of the lymph glands beneath the lower jaw on the diseased side or on both sides. Swelling of the submaxillary glands

sometimes occurs very early. Not infrequently marked swelling of the glands takes place, which now and then suppurate, and, in consequence of infection from the micro-organisms within the mouth, may occasion diffuse phlegmonous processes. The pain from carcinoma of the tongue is often severe, and frequently radiates as far as the ears. An increased secretion of the mucous membrane of the mouth, and especially of saliva, is the rule.

The further course of the disease is very unfavourable, and its victims are much to be pitied. A typical ulcerating carcinoma of the tongue usually spreads rapidly, and attacks, according to its position, the floor of the mouth and the jaw, or, if its seat is in the posterior region of the tongue, the soft palate, hard palate, tonsils, and epiglottis. In case of very extensive carcinomatous ulceration, lockjaw often occurs, so that the teeth, which are firmly pressed together, can be forcibly separated by a mouth gag only while the patient is under an anæsthetic. It is often in this condition that the patient first comes to a surgeon, and, after the mouth has been forcibly opened, the extensive destruction produced by the carcinoma is revealed, which is attended with an extremely foul breath. As it involves more and more of the tongue, speech and swallowing are interfered with, and the patient suffers especially from the offensive sloughing. Death ensues from increasing marasmus, inanition, pneumonia, sepsis, and from intercurrent hæmorrhages.

The course of carcinoma varies in length. A large majority of patients who are not operated upon die within a year or a year and a half from the beginning of the disease.

Metastases in the internal organs are not frequent.

The diagnosis of a typical ulcerating carcinoma of the tongue is, in accordance with the description that has just been given, usually not difficult. It may be confounded with syphilitic or tubercular ulceration, with non-malignant induration and ulceration, and with papilloma. Infiltrations about chronic abscesses and foreign bodies that have healed up in the tongue may also be confounded with carcinoma. As already stated, I once operated upon what was ostensibly a carcinoma of the tip of the tongue, and found in the infiltrated, non-carcinomatous area a loop of silk which had healed in. The silk had been used by a former surgeon to suture a wound in the tongue, and had been only partially removed.

In all cases in which a carcinoma is suspected a careful microscopic examination of the scraped-off coating of the ulcer and of small excised portions, especially from the edges, should be made previous to the operation. The carcinoma should be carefully cleansed before the material for examination is removed.

It is especially indicative of carcinoma if in the tissue that has been scraped off after the ulcer was cleansed the characteristic spheres and nests

of epithelial cells are found. In carcinoma the epithelial cells are found in active proliferation, and they contain two, three, and even more nuclei. The histological examination of small excised pieces gives positive evidence. In a non-ulcerating carcinoma the microscopic examination of the coating that has been scraped off is, of course, negative. The histological examination of an excised portion gives also the surest conclusion in case of tuberculosis and syphilis; in tuberculosis particularly by finding tubercle bacilli.

The age of the patient is also an important consideration in the diagnosis of carcinoma. It does not appear before the fortieth or fiftieth year, whereas tuberculosis and syphilis are found, as a rule, earlier. An exact personal history should, moreover, always be demanded, and a careful examination of the patient made to determine whether other tubercular or syphilitic manifestations have existed or still exist.

In every carcinoma, but more particularly in that of the tongue, the possibility of recovery depends upon an early diagnosis. The earlier the carcinoma is recognized, the greater is the probability of saving the patient by timely operation.

The prognosis of carcinoma of the tongue has been sufficiently indicated already. If it is not radically extirpated by cutting through sound tissue at an early stage, the patient will surely die, usually in from one to three years, sometimes sooner. According to Butlin, of one hundred patients operated upon, about ten are permanently cured. Barker, also, counted seventeen permanent cures among one hundred and seventy cases operated upon. Of eighty patients seen by Butlin, seventy were operated upon; and of the latter, nine, or thirteen per cent, were cured—that is, went more than a year without recurrence. The period of observation after the operation in the case of these cures was from seventeen months to two, four, six, and eleven years. Between 1878 and 1888 Czerny operated upon twenty-six patients, with a mortality of 14·3 per cent. More exact information was obtained concerning sixteen of those operated upon. Fourteen died from recurrence; only one was free from recurrence two and a quarter years after the operation. Of one hundred and thirty-nine patients of Whitehead's, 14·3 per cent likewise died from the operation. Of one hundred and four total excisions, 19·2 per cent proved fatal. From mere extirpation of the tongue the mortality amounted to but 4·5 per cent. After simultaneous removal of glands and operations upon the bone, fifty-seven patients, or seventy-seven per cent, died. Whitehead obtained further information concerning sixty-one of those operated upon. Fifteen survived the operation for one year, four for two years, two for three years, four for five years, one for six years, and one for fourteen years. Out of thirty-eight operated on by Kocher thirteen or 34·3 per cent were without recurrence for periods varying from one to eight years; of sixty-four cases of Billroth's ten were free from recurrence from one and one third to eight years afterward. Even if a permanent cure is not accomplished by the operation, life is as a rule lengthened, the pain is alleviated, and the general condition of the patient often improved.

The treatment of carcinoma of the tongue is principally operative, and the earlier the tumour is radically extirpated the better.

Prophylaxis is of the greatest importance—that is, one should try to heal any suspicious ulcers upon the tongue as promptly as possible, by excision, it may be, though they be not as yet carcinomatous. Carcinoma may arise from any ulcer of the tongue of long standing, though it be of a non-malignant character at first. For the same reason, benign papillary or adenomatous growths on the tongue should be radically removed. It is very objectionable to treat ulcers of the tongue or incipient carcinoma too long with caustics, because the growth of a carcinoma is only helped by the severe irritation, and the favourable time for extirpation is lost. It is an important matter of experience that all irritation of the tongue, especially in case of persons in whom it is sensitive, should be avoided. The strictest care is to be exercised in such cases with regard especially to smoking and the taking of highly seasoned food or alcohol. The development of carcinoma of the tongue could often be prevented also by the timely removal of sharp stumps of carious teeth.

Were such prophylactic measures as those just mentioned used by all physicians, the number of cases of carcinoma of the tongue would, at any rate, be smaller.

§ 61. **The Operative Treatment of Carcinoma of the Tongue.**—In removing a carcinoma of the tongue one should, as a general rule, include the sound parts at a distance of at least one centimetre from the edge of the tumour. The more radical the operation, the more probable is a permanent cure.

The history of carcinoma of the tongue and its treatment by operation have recently been worked up by Wölfler in a clear and comprehensive manner. He also gives an exact report of forty-five cases, operated upon by Billroth during the preceding two and a half years. This work is to be highly recommended to any one who wishes to inform himself more thoroughly upon this subject (Arch. für klin. Chirurgie, 1881, Bd. xxvi, Heft 2).

The extirpation of a carcinoma of the tongue must be undertaken with the strictest antiseptic precautions. It is very important that the mouth be carefully cleansed with disinfecting washes before the operation, and tartar and roots and stumps of carious teeth are to be removed. Sloughing carcinomatous ulcers should be cauterized beforehand by the thermo-cautery or a strong caustic. To check the hæmorrhage attendant upon the removal of very large carcinomata, the preliminary ligation of the lingual artery on the side involved, or on both sides, is, properly, the general practice. Regarding the aspiration of blood and pus into the air passages and the prevention of aspiration pneumonia, the same rule holds here that we have given more in detail

in connection with operations on the jaws (§ 53, page 348). Preliminary tracheotomy and tamponing the trachea are often necessary, especially in case of total extirpation of the tongue. After the operation is over, the pharynx and entrance to the larynx may then be packed with iodoform gauze. After the extirpation of extensive carcinomata, and especially after the complete removal of the tongue, nourishment is given by means of the stomach tube.

Small nodules and ulcers are removed under cocaine by a cuneiform incision with scissors or knife. The defect is then immediately closed by deep sutures of fine silk or catgut. If, in removing a carcinoma from the tip of the tongue, it is desired to operate with as little loss of blood as possible, one may pass a ligature around both ranine arteries by passing a curved needle transversely through the middle of the tongue near the frenum, close above a caruncula sublingualis, about one and a half centimetres external to the median line, and tying the two ends of the suture. In case of operation on but one side, this temporary ligation would be necessary only on the side involved. After finishing the operation the loop is cut and removed. This procedure is usually unnecessary, as the hæmorrhage is arrested immediately by suturing rapidly. For excisions reaching farther back, Langenbeck has recommended temporary ligation *en masse* through the base of each half of the tongue. Smaller carcinomata may also be removed with the cautery without hæmorrhage.

If an anæsthetic is employed, the mouth is held open by means of the mouth gags represented in Figs. 221–223, page 363, and the tongue is drawn sufficiently far forward by means of a loop of silk passed through it. The diseased part is then seized with mouse-toothed forceps and excised with scissors or the knife.

In the removal of larger carcinomata of the tongue, especially those that reach far back, special precautions are to be taken, both for limiting the loss of blood and for securing free access to the tumour.

To diminish the hæmorrhage in the removal of large carcinomata or those which are situated far back, unilateral or bilateral ligation of the lingual artery in continuity is most frequently resorted to. It is described in detail in § 62, page 395. In extirpation of one half of the tongue, the ligation of the lingual artery on the side involved is usually sufficient, though it is always safer to tie both. From the wound that is thus made any carcinomatous lymph glands may be removed at the same time. In case of deep-seated carcinomata of the tongue, Wölfler properly recommends that the facial artery also be tied beforehand. Démarquay has recommended, moreover, the tying of one or both of the lingual arteries, even in inoperable cases of carci-

noma of the tongue, in order to check its growth and lessen the pain and other symptoms.

We have already spoken of the plan of passing a ligature around the ranine arteries in connection with operations upon the tip of the tongue, and of temporary ligation *en masse* through its base.

Hæmorrhage may also be controlled by means of the écraseur, galvano-cautery, or Paquelin's thermo-cautery.

The crushing off of the portion of the tongue affected by carcinoma (see Principles of Surgery, page 73) has now fallen more or less out of use. If it is desired to crush off the free part of the tongue, for example, it is drawn out as far as possible by means of a loop of thread or vulsellum forceps; two steel needles are then passed perpendicularly through it from above and the chain of the écraseur is laid around the tongue behind these needles. The needles are inserted to keep the instrument from slipping off. The crushing off of a lateral half of the tongue is more difficult. The removal in this way of the whole tongue at its base is done as follows: The floor of the mouth is divided, after Chassaignac and Maisonneuve, in the median line as far as the root of the tongue by an incision on the neck, and then by introducing a needle into the mouth through this incision a thread is passed around the root of the tongue and brought out again through the same incision. By the help of this thread the chain of the écraseur is laid around the base of the tongue and the latter is gradually crushed through. The slipping of the chain is prevented by sharp hooks stuck into the tongue from in front.

If removal with the écraseur is to be accomplished without loss of blood the operation must be performed very slowly—that is, the lever should be allowed to advance a tooth about once a minute.

The removal of a portion of the tongue by a galvano-cautery loop is accomplished by placing this in position in much the same way as the chain of the écraseur. The wires must be thick and the current weak in order that the heat may not be too great, as otherwise the bleeding is not stopped. The destruction of a carcinoma of the tongue by the galvano-cautery or Paquelin's thermo-cautery is only to be recommended in case the carcinoma is situated far forward, and it is done in accordance with the rules given in Principles of Surgery, page 74 ff. The removal of the greater part or even the whole of the tongue may be accomplished with the thermo-cautery. Lips and cheeks are protected by an ivory speculum (Langenbeck). It is unnecessary to saw through the jaw, but both lingual arteries should be ligated in continuity. To insure arrest of hæmorrhage, the instrument should not be heated to its full extent. Bottini in particular, on the ground of a very large experience, recommends operation with the galvano-cautery. He performs complete as well as partial extirpations through the mouth without any accessory operation. He lost out of one hundred cases only seven as a direct result of the operation.

When the carcinoma is situated far back and the greater part or the whole of the tongue is to be removed, sufficient access to the field of operation must be secured either by a division of the outer soft parts,

from the corner of the mouth, for example, or, still better, by temporary resection of the jaw.

By division of the soft parts from the corner of the mouth in a transverse direction, after Jäger, Rose, and others (see Fig. 232, 1), but little room is secured, yet this method is in certain cases very serviceable.

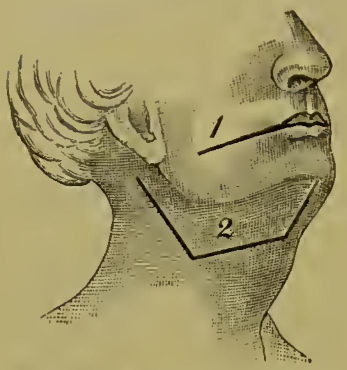


Fig. 232.—Extirpation of carcinoma of the tongue: *1*, division of the external soft parts after Jäger, Rose, and others; *2*, Kocher's method.

Kocher recommends an angular incision in the submental region, as shown in Fig. 232, 2, especially for carcinomata which involve the side of the tongue near the anterior palatine arch. Kocher's incision is made from the chin in a straight line to a point midway between the latter and the hyoid bone, then from here transversely to the anterior border of the sterno-mastoid muscle, and finally from here at an obtuse angle upward as far as the tip of the ear. This flap of skin thus marked out (Fig. 232, 2) is dissected from the subjacent parts and turned upward. After tying the facial and lingual arteries and the facial vein and removing the submaxillary gland and any carcinomatous lymph glands there may be, the mylo-hyoid muscle is divided and the cavity of the mouth opened. There is now a view through the wound of the entire border of the tongue as far as the epiglottis, and the removal of the carcinoma can be conveniently undertaken.

Regnoli and Billroth have likewise made the field of operation accessible from the submental region, in order, if necessary, to remove from here the whole tongue. These two methods give the most room. To Regnoli belongs the credit of first devising the submental method of extirpating the tongue.

Regnoli first divides the submental region in the median line from the chin to the middle of the hyoid bone, and then from the beginning of this median incision carries incisions on both sides along the border of the lower jaw to the anterior edge of the masseter (see Fig. 233). The facial artery is spared if possible. Through this incision he now divides the muscles whose insertions are on the chin (mylo-hyoid, genio-hyoid, and genio-glossus), and finally, by cutting through the mucous membrane, gains access to the mouth on both sides. The tongue must be drawn forward by an inserted loop of silk or by vulsellum forceps to prevent its falling back and causing suffocation after the genio-glossi are severed from the chin. Finally, after the opening has been made into the mouth, the tongue is drawn forward below the lower jaw and can be entirely removed with ease.

Billroth has made a useful modification of Regnoli's method. He makes a curved incision about five centimetres long in the soft parts beneath the chin, and then at the ends of this incision a lateral one on each side about three centimetres long. These terminate on both sides external to the cornua of the hyoid bone (see Fig. 233 ⊓). Along the whole length of the curved incision on the chin the soft parts, together with the periosteum, are freed from the inner surface of the jaw with the knife and periosteal elevator. The knife is used especially for dividing the insertions of the muscles. The mucous membrane is then divided along the inner alveolar border and entrance is gained to the mouth. The tongue is then drawn out through this wound and removed.

For the removal of carcinomata that have involved the floor of the mouth or that are situated at the base of the tongue the division of the lower jaw with a saw is to be recommended. This may be accomplished in the median line of the jaw (Sédillot), on both sides (Billroth), or on one side (Langenbeck). After the jaw has been sawn through, the field of operation is so conveniently accessible for arresting the hæmorrhage that preliminary ligation of the lingual arteries may be dispensed with, though it is here also strongly to be recommended. Preliminary tracheotomy, on the other hand, is usually necessary, in order to prevent, by tamponing the trachea, the aspiration of blood, pus, and sloughing tissue into the air passages during and after the operation.

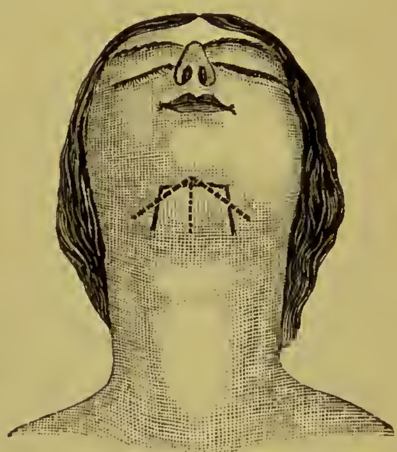


Fig. 233.—Excision of the tongue: Regnoli's incision; ⊓ Billroth's incision.

Division of the lower jaw in the median line after Sédillot is especially suited for carcinomata of the anterior part of the tongue with simultaneous disease of the floor of the mouth. The lower lip is split in the median line, and after dividing the gum and periosteum and extracting a central incisor, the lower jaw is sawn through. A skin incision is now made on both sides along the lower border of the jaw, in order to be able to sever close to the bone the insertions of the mylo-hyoids, genio-hyoids, and genio-glossi. After severing the insertions of these muscles the halves of the divided jaw can be drawn sufficiently apart and the removal of the tongue with a portion of the floor of the mouth undertaken. The soft palate and the tonsils may also be conveniently removed by this method of sawing through the jaw, and each spurting vessel can be caught and tied. After the removal of the

carcinoma the halves of the jaw may be united by wire sutures or one or two aseptic nails.

Langenbeck's method of sawing through the jaw laterally is as follows (Fig. 234): The soft parts are divided by an incision on the side affected from the corner of the mouth perpendicularly downward as far as the upper border of the thyroid cartilage. Through this incision are removed any carcinomatous lymph glands in the submaxillary region, and the lingual artery is tied. The digastric and hyoglossus muscles are then divided. The jaw is next sawn through obliquely from above and outward, downward and inward, so as in this way to avoid as far as possible a later displacement of the halves of the jaw. After separating the halves by means of sharp hooks the insertion of the mucous membrane is cut on the lateral part of the jaw as far back as the anterior palatine arch, and the field of operation is now easily accessible. The soft palate and tonsils can be easily removed when necessity requires. If the carcinoma encroaches beyond the middle line, the lingual artery on the other side should also be tied through the same wound. After extirpation of the carcinoma the two sawn surfaces of the jaw are united by silver wire or one or two nails, a drain is placed in the lower angle of the wound and another behind the angle of the jaw, and the external wound is sutured. If tracheotomy was performed previously to the operation, the wound cavity may also be packed with iodoform gauze.

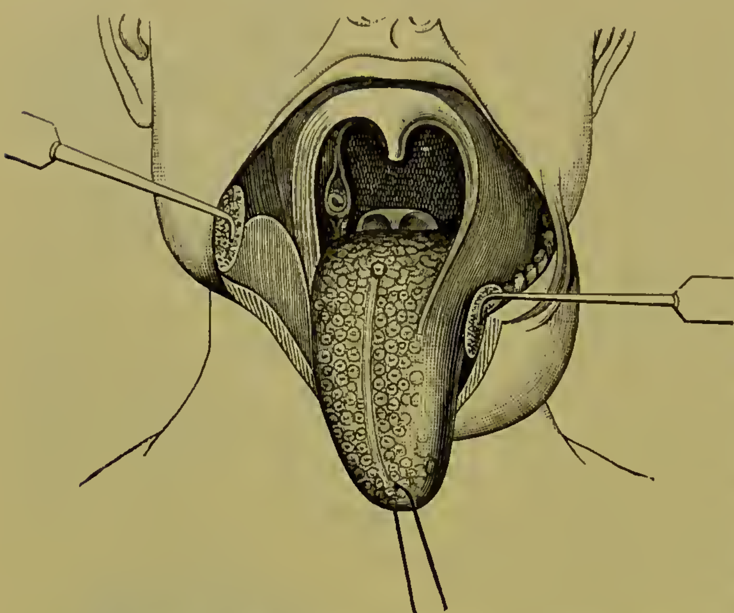


FIG. 234.—Excision of the tongue with the aid of lateral division of the lower jaw (Langenbeck.)

Crespi and Bastianelli have modified the method of Langenbeck's, which has just been described, in the following manner: The ⅃-shaped incision in the soft parts divides the lower lip in the middle line as far as the symphysis of the lower jaw, is then carried along the border of the jaw to the vicinity of the angle, and then curves downward along the anterior edge of the sterno-cleido-mastoid muscle. Then the lower lip is freed to a point two centime-

tres from the insertion of the masseter, the submaxillary triangle is cleaned out, the lingual and facial arteries ligated centrally and peripherally and divided, and the lower jaw sawn through obliquely from behind forward in front of the last molar but one (according to Langenbeck's method, between the canine and the first bicuspid). Tracheotomy is not necessary. In case of any difficulty in respiration, Schrötter's canula is introduced into the larynx.

In Billroth's method of sawing through the lower jaw bilaterally, the soft parts are divided by two perpendicular incisions from the corners of the mouth to the hyoid bone, and, after the gum and periosteum have been incised and any teeth standing in the way have been extracted, the jaw is sawn through on both sides corresponding to the external incisions. After separating the soft parts from the inner surface of the jaw, the resected middle piece can be displaced forward.

Of the methods already mentioned for the extirpation of extensive carcinomata or those that reach far back, the submental methods of Regnoli-Billroth and Kocher and Langenbeck's method are most strongly to be recommended. The submental method of Regnoli-Billroth is especially adapted to cases of carcinoma of the body of the tongue with simultaneous disease of the floor of the mouth, that of Kocher for those in which the tumour extends farther back. By the use of Langenbeck's method the soft palate and tonsils may also be removed with great ease.

If, in case of carcinoma of the tongue, the lower jaw is likewise diseased, the part that is affected must, of course, be removed at the same time.

After complete extirpation of the tongue, the after-treatment consists in packing the cavity with iodoform gauze and feeding the patient for a time through a stomach tube. Whitehead applies to the wound, after it has been disinfected and dried as thoroughly as possible, Friar's balsam (compound tincture of benzoin with saturated iodoform-ether solution instead of alcohol), which forms a membrane that adheres for about twenty-four hours. It is in this way possible, according to Whitehead, to feed the patient through the mouth on the second day.

The functional disturbances following complete removal of the tongue have been studied in detail by Ehrmann. In case of entire absence of the tongue, the functions of mastication and deglutition are considerably interfered with and speech is very much disturbed, with the exception of the labial sounds. The pronunciation of the lingual and palatal sounds is most affected. With the co-operation of the other aids in articulation the patient is able to speak so as to be sufficiently understood. Enunciation of the consonants is more difficult than that of the vowels. The sense of taste, which is located principally in the posterior portion of the oral cavity, is disturbed the least of all.

In cases of removal of the entire tongue Poncet recommends the use of an artificial tongue invented by Martin, of Lyons. It consists of a very light

middle piece, shaped like a horseshoe, which is supported upon the lower teeth much the same as an artificial plate. To this middle piece is attached a small articulating rod with a red bag of India rubber, shaped like the tongue, filled with fluid. Patients provided with this apparatus can, according to Poncet, eat well and speak intelligibly after they have become accustomed to it.

In inoperable carcinoma of the tongue, the suffering of the patient may be relieved by palliative operations, such as the application of the thermo-cautery, neurectomy of the lingual nerve (see page 252) if the pain is severe, and, finally, ligation of the lingual arteries, in order to retard the growth of the carcinoma by the resulting atrophy of the tongue.

§ 62. **Ligation of the Lingual Artery** is best performed, according to Guérin, Pirogoff, and Hueter, in the submental region between the lower jaw and the hyoid bone, or more exactly above the greater cornu of the hyoid.

The head of the patient is inclined backward and toward the opposite shoulder, and an incision four or five centimetres long is made parallel to the upper border of the hyoid bone from the greater cornu to a point about one centimetre from the median line of the neck. In making this incision the facial vein lying in the lateral part of the wound must be avoided. After division of the skin and the platysma, the submaxillary gland becomes visible. The lower edge of the latter is freed on all sides bluntly or with slight cuts, and then drawn upward with a blunt retractor. The so-called sublingual or hypoglossal triangle is now seen, whose floor is formed by the hyoglossus muscle (see Fig. 235). The outer side of the triangle is bounded by the posterior belly of the digastric muscle and the stylo-hyoid. To the inner side lies the free border of the mylo-hyoid muscle, and above the hypoglossal nerve, still covered with loose tissue, passes across in a slightly curved direction with the ranine vein. The lingual artery lies in this triangle, cov-

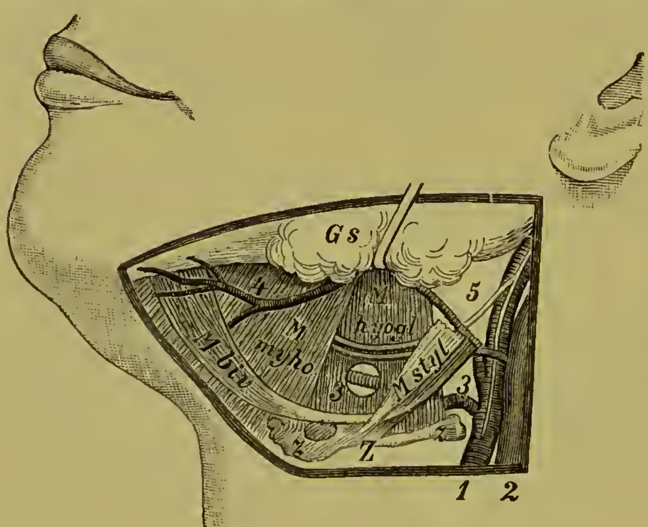


FIG. 235.—Ligation of the lingual artery: The submaxillary gland (*Gs*) is retracted upward; *Z*, hyoid-bone; *1*, external carotid artery; *2*, internal jugular vein; *3*, lingual artery; *4*, submental artery retracted upward; *5*, hypoglossal nerve.

ered by the hyoglossus muscle and beneath and parallel to the hypoglossal nerve. The fibres of the hyoglossus just below the hypoglossal nerve are carefully lifted up with two mouse-toothed forceps, and then divided transversely between the latter. The lingual artery is now seen and tied. If the artery should not be found here, owing to its taking an abnormal course, the operator may work outward toward the external carotid, and by drawing this to the outer side put the lingual artery on the stretch (Linhart).

Fixation of the hyoid bone, and drawing it forward by means of a sharp hook, are strongly to be recommended, in order to prevent constant motion of the wound during the operation.

It is less advisable to tie the lingual near the point where it branches off from the external carotid before it passes beneath the border of the hyoglossus (Mirault, Roser), or, according to Malgaigne and Béclard, behind the hyoglossus, in the angle between the posterior belly of the digastric and the upper border of the hyoid bone (see Fig. 235). The last method is the most difficult, so that even those who advised it could not always execute it.

The method of Guérin, Pirogoff, and Hueter, more exactly described above, still remains the best.

Ligation of the lingual artery is, as we saw, especially indicated as a preliminary step to the extirpation of carcinoma of the tongue, for the sake of controlling the hæmorrhage, and it is usually done in these cases on both sides. It may also be necessary on account of hæmorrhage following injuries to the tongue, in case the bleeding can not be arrested in the wound itself. Hueter has also recommended it for macroglossia, and Démarquay for the sake of checking the growth of carcinoma of the tongue.

§ 63. **Congenital and Acquired Defects of the Hard and Soft Palate.**—We have already become familiar with congenital clefts of the hard and soft palate under the subject of harelip (see page 184 ff). Clefts of the hard palate are either unilateral or bilateral, while those of the soft palate always run in the median line. The cleft soft palate consists, therefore, of two similar halves, with the corresponding muscles (levator and tensor palati). In the mildest degree of cleft of the soft palate the uvula only is divided (uvula bifida). Small oval longitudinal clefts occasionally occur in the anterior palatine arches near the point where they merge into the tongue. These have, however, no practical significance. Clefts of the soft and hard palate also occur without harelip. If a cleft of the hard palate extends through the alveolar process of the upper jaw as well, there is always a cleft of the lip and a typical deformity called "wolf's jaw."

Acquired defects or clefts of the hard and soft palate arise most frequently from late syphilitic processes, less often from tuberculosis or traumatisms. In the case of a man forty-nine years old with no history of syphilis, who had a fall upon his head attended with unconsciousness (probably fracture of the base of the skull), Baudet observed, five months after the accident, gradual absorption of the hard palate and the alveolar border of the upper jaw, with loss of all the teeth of the upper jaw. Labbé, Dolbeau, Duplay, Dubreuil, and Kirmisson have made similar observations. It is probably a neurotic absorption of bone resulting from injury to the brain.

The form, situation, and extent of acquired defects in the hard and soft palate are very variable. The defects lie most frequently in the median line. Not infrequently the greater part of the soft palate is destroyed, especially by syphilitic ulcers, so that in its place a large gap with cicatricial distorted edges is seen.

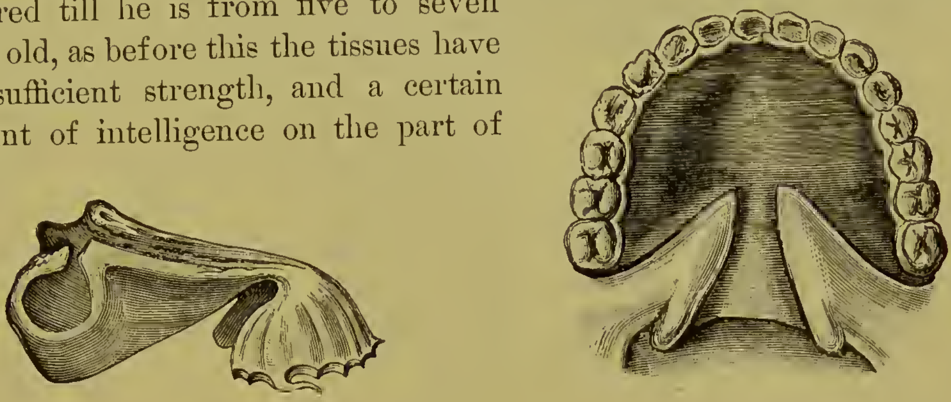
The functional disturbances arising from congenital and acquired defects in the hard and soft palate are essentially the same. Among these are disturbances of speech and a mingling of the contents of the nose and mouth. The speech has a strikingly nasal character, and the greater the defect the more it is disturbed, so that it may become altogether unintelligible. Children with harelip and cleft palate can, it is true, drink from a bottle with a long India-rubber stopper; but disturbances of digestion and nutrition, or thrush, resulting from the flow of milk into the nose and its subsequent stagnation there, arise only too easily. In case of acquired defects, the difficulties in swallowing are not extreme, as patients gradually learn to adjust and modify the inconveniences.

Treatment of Defects of the Palate.—The treatment of congenital and acquired defects of the palate may in the first place be operative; on the hard palate uranoplasty is performed, and on the soft palate staphylorrhaphy or suture of the freshened edges of the defect. Then, again, defects of the palate may be closed by obturators of vulcanized rubber (Fig. 236 *a*). These are now prepared by dentists in a most excellent manner. Defects in the hard palate are best closed with hard-rubber plates which are provided with artificial teeth, just as in case of loss of teeth. The construction of obturators for defects in the soft palate is more difficult. The obturators recommended by Schiltsky and J. Wolff are here very useful. They are elastic, and to be filled with air like a balloon. They are fitted in between the soft palate and the wall of the pharynx, and are held firmly in place by a palate plate (see Fig. 237, page 400). The results obtained by the use of obturators, especially in case of acquired defects, are very gratifying.

Speech becomes distinct and almost normal. With reference to the treatment of defects of the jaws and palate by means of artificial appliances, the reader is referred particularly to the Handbuch der Zahnersatzkunde, by J. Parreidt, Leipsic, Arthur Felix, 1893.

As regards treatment, congenital and acquired defects of the palate are to be strictly distinguished, especially with reference to whether the gap is to be closed by operation or by an obturator.

Congenital clefts of the palate are best closed by operative means. In case of cleft of the palate with harelip the defect in the lip is closed first, as we saw (§ 25, page 191), during the first months of the child's life, the closure of the clefts in the hard and soft palate being deferred till he is from five to seven years old, as before this the tissues have not sufficient strength, and a certain amount of intelligence on the part of the patient is necessary during the after-treatment. Recently, however, Julius Wolff, who has obtained excellent results from uranoplasty and staphylorrhaphy, has operated with success upon congenital clefts of the hard and soft palate in the second and third year, and in three cases upon children respectively three, five, and ten months old. He recommends in these early operations, in order to diminish hæmorrhage, methodical compression of the wound with aseptic gauze tampons during pauses in the operation lasting several minutes. J. Wolff's success shows that cures are possible with an early operation. I myself, in common with other surgeons—Schede, for instance—have had no success in operations performed during the child's first year, and I do not perform uranoplasty and staphylorrhaphy until a child is five years old.



a *b*

Fig. 236.—Suersen's obturator (*a*); (*b*), inserted into the defect in the palate.

The closure of the hard and soft palate is either done at one sitting, or uranoplasty (see page 401) may be performed first and staphylorrhaphy some time afterward. According to Julius Wolff, the operation upon children in the first years should be performed under an anæsthetic, with the patient's head hanging over the end of the table,

use being made of the methodical compression of the wound which has been mentioned. The operation is done in two stages, the flaps being separated first, and the freshening and suture following from five to eight days later.

After the operation has been successfully accomplished the children should receive methodical instruction in speaking. Küster speaks highly of the methods of instruction used by A. and H. Gutzmann, who have reported ninety-three cases. They recommend operation in the fifth or sixth year, as the speech exercises should begin soon after the operation, and these exercises can hardly be commenced before this age. Success in the matter of speech is somewhat interfered with by the fact that the soft palate is too small and can not reach the posterior wall of the pharynx. To meet this difficulty and overcome the nasal speech that it causes, J. Wolff and Schiltsky recommend the elastic obturators filled with air which have been mentioned above. These are fitted in between the soft palate and the posterior wall of the pharynx, and shut off the nasal cavity. A palate plate of hard India rubber (Fig. 237) carries upon a narrow stem lying over the soft palate a small, hollow obturator of soft vulcanized India rubber filled with air. As soon as the soft palate rises in the act of speaking, etc., it forces the air in the compressible obturator backward and sideways, so that the naso-pharyngeal space is shut off and the speech is clear and without the nasal tone. If the operation is performed in the earliest years the obturators are often unnecessary.

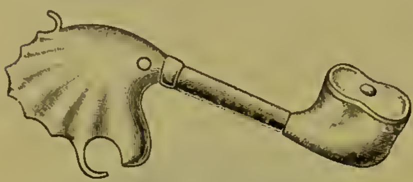


FIG. 237.—The Schiltsky-Wolff obturator.

Operations upon acquired defects of the hard and soft palate also give very good results if the portions that are destroyed are not too large. In case of too large defects the obturator is used. Acquired gaps should never be operated upon so long as ulcerative processes still exist.

Defects situated in the median line are best suited for operation. Pedunculated flaps from the immediate vicinity of the defect may be laid over it and typical uranoplasty then performed. Thiersch closed a large lateral defect in the palate, caused by a gunshot wound after removal of the alveolar process on that side, by a pedunculated flap taken from the entire thickness of the cheek in such a way that the skin surface was turned toward the interior of the mouth. Rose has successfully closed defects with flaps from the mucous membrane of the lips. Small defects may be closed by cauterizing the edges with the galvano-cautery, which should not be heated too strongly.

As a substitute for staphylorrhaphy Passavant sutured both halves of the soft palate to the posterior pharyngeal well. Schönborn and Trendelenburg sutured a flap of mucous membrane from the posterior wall of the pharynx into a defect in the soft palate ("staphyloplasty"). These methods are not to be recommended, as the patients, in consequence of shutting off the nose from the mouth, could only breathe through the mouth and could not blow the nose. Smell and hearing were also affected. In short, the inconveniences were in many cases such that it was necessary to restore the original condition.

Mosetig-Moorhof, in a case of adhesion of the soft palate with the posterior wall of the pharynx, established with satisfactory results a permanent communication between the nose and the mouth, behind the incisors, corresponding to the anterior palatine canal. He therefore recommends combining Passavant's method and Schönborn's staphyloplasty with the formation of a fistula at the site of the anterior palatine canal, and thus improving the results of this operation.

In all cases of acquired defects of the palate which can not be operated upon, Schiltsky's obturators, which have been mentioned above, are to be recommended as a means of obviating nasal speech. They have the advantage that they can be easily removed, at night for instance, and replaced.

The Technique of Uranoplasty.—Uranoplasty, or the operation for closing clefts in the hard palate, is at present performed by Langenbeck's method only.

The operation is performed either with the head hanging over the end of the table while the patient is fully anæsthetized, or, in case of persons with a strong will, with the patient in a sitting posture and under a mixed morphine-chloroform narcosis. Cocaine is also to be strongly recommended. The whole palate is swabbed for five minutes with a five- to ten-per-cent solution of cocaine, after which the palate is not only deprived of all sensibility, but contraction of the muscles and choking are also temporarily suspended, which is of importance for the further progress of the operation.

Fig. 238.—Retractors for the corners of the mouth.

Anæsthesia in case of operation with the head hanging over backward is best secured by the use of Junker's apparatus (see Principles of Surgery, page 21, Fig. 18); the chloroform vapour is made to pass from the mouth or nose directly into the throat through a metallic tube, bent at an acute angle, with an India-rubber insertion (E. Rose).

The corners of the mouth are drawn apart by holders which are united by a band of India rubber passing around the head and back of the neck (see Fig. 238); or one of the mouth gags which have been

described, especially that shown in Fig. 223, page 363, may be used, in which case the holders for the corners of the mouth are unnecessary.

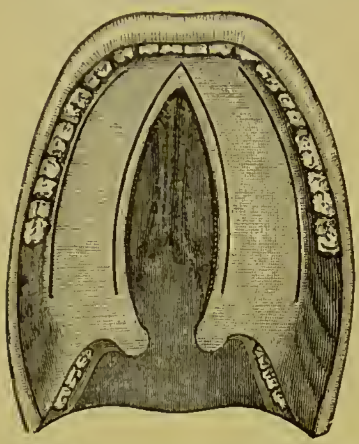


Fig. 239.—Uranoplasty (Langenbeck).

Hæmorrhage during the operation is best checked by occasional protracted compression of the wound by means of stick sponges.

Uranoplasty involves three steps: (1) Freshening the edges of the cleft, (2) separating the muco-periosteal covering of the hard palate, (3) suture.

The edges of the cleft are freshened by cutting somewhat obliquely from before backward, the incision extending into the soft palate (see Fig. 239). The best instrument for this purpose is a convex knife, recommended by Langenbeck, curved so as to correspond to the arch of the palate (see Fig. 240 *a*). A longitudinal incision is then made down to the bone on each side, parallel to the first incisions and close to the crowns of the teeth, running from the lateral incisors to the wisdom teeth or somewhat farther (see Fig. 239). The flaps of soft parts thus cut, with anterior and posterior nutrient bridges, are now freed from the bone, beginning at the teeth, by means of a narrow, sharply curved elevator. The bleeding that is thus caused must be controlled by occasional compression with stick sponges. Special care must be taken that the posterior portion of each flap is made sufficiently movable and that the soft palate is separated from the posterior border of the palate bone. The best instrument for this purpose is Langenbeck's knife curved on the flat, which is represented in Fig. 240 *b* and *c*. After both flaps have been detached they are approximated in the median line so as to cover the cleft and united by sutures. For suturing, it is best to use Hagedorn's fine flat needles with a full curve and a Hagedorn needle holder. It is also a very good plan to use round curved needles which can be held in the

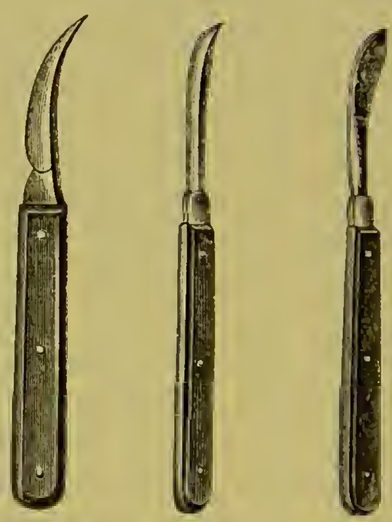


Fig. 240.—Langenbeck's scalpels for performing uranoplasty: *a*, convex blade for cutting the flap on the hard palate; *b*, pointed double-edged blade curved on the flat; and *c*, the same, but blunt-pointed for separating the velum from the posterior border of the palate bone.

holder in any position. Fine aseptic silk or catgut serves as suture material. The stitches are all placed in position first without tying them. In order to prevent any confusion among the threads from this source, those that belong together may be fastened into a piece of pasteboard provided with notches (Fig. 242). Langenbeck has suggested for this a special forehead bandage. After the sutures have all been applied they are tied, whereby attention must be paid to securing as good coaptation as possible of the edges of the wound. The threads are cut off short.

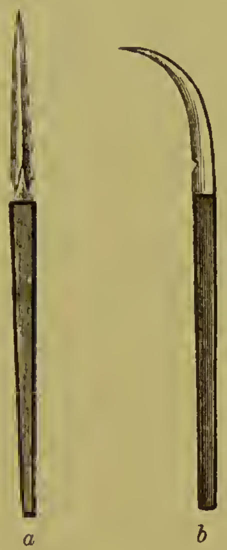


FIG. 241.—Scalpels for performing staphlorrhaphy: *a*, double-edged lance-blade; *b*, curved tenotome for tenotomy of the levator palati and tensor palati muscles.

In case of a very wide cleft palate on one side, where Langenbeck's uranoplasty, which has just been described, is very difficult or impossible, the gap may be covered by separating and turning down the nasal septum (Sabatier), or its mucous membrane (Lannelongue). In the first case the nasal cavity is opened from the furrow between the nose and cheek, the nasal septum is separated from the base of the skull and roof of the nose with hammer and chisel, and, by bending it down so as to sever its connection with the hard palate, it is laid into the defect. If there is not sufficient mucous membrane on the hard palate, the cleft could be bridged over with a flap of soft parts and bone taken from the alveolar process (Julius Wolff).

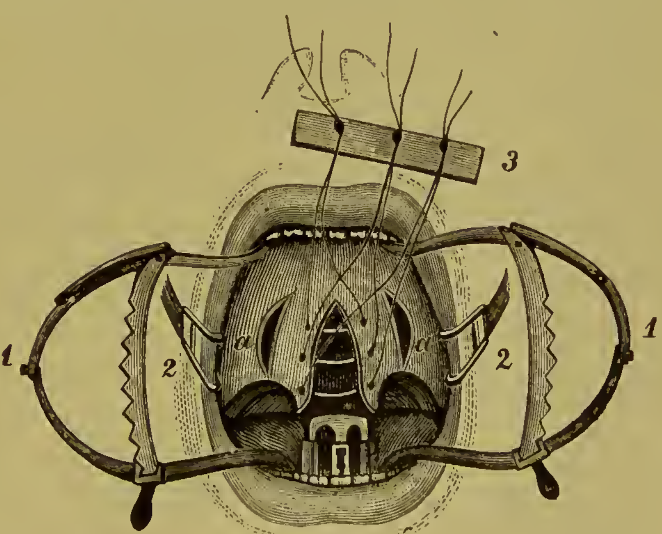


FIG. 242.—Staphylorrhaphy: *1*, Whitehead's mouth gag; *2*, cheek retractor; *3*, pasteboard with notches for holding the sutures; *a*, liberating incisions.

The after-treatment of uranoplasty consists in rest, giving liquid food, antiseptic washes, and in irrigating the nasal cavity with disinfecting solutions. The stitches are removed in from three to six days. After healing, the defect is finally closed by bone through bone formation on the part of the periosteum.

The Technique of Staphylorrhaphy.—Staphylorrhaphy, or suture of the soft palate, should be performed, in case there is a simultaneous cleft of the hard palate, at the same sitting with uranoplasty. The freshening of the edges of the cleft in the soft palate is done as follows: The uvula is seized and stretched by means of a tenaculum, and the edges are cut at one stroke with a two-edged scalpel (see Fig. 241 *a*). This paring is done obliquely—that is, more is taken away from the anterior side of the soft palate in order to secure broader wound surfaces. The sutures are placed in the manner described above in connection with uranoplasty. To relax the line of suture a liberating incision is made on each side, before or after the stitches are taken, parallel to the edges of the cleft, dividing the muscles of the soft palate (Dieffenbach and Fergusson); or tenotomy of the levator palati and palato-pharyngeus muscles on the hamular process is performed with a sharply curved knife (see Fig. 241 *b*). Langenbeck added to this a short incision through the soft palate, not exceeding three quarters of an inch in adults.

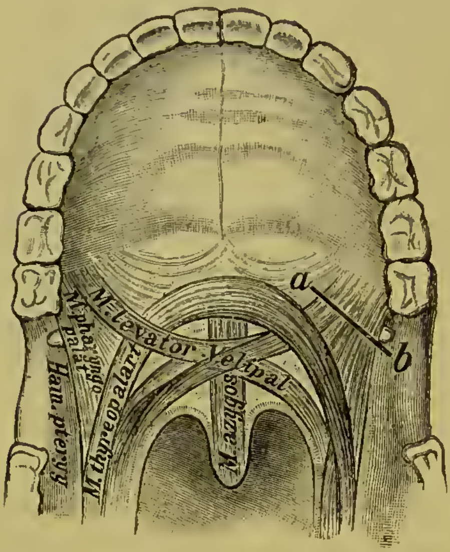


Fig. 243.—Muscles of the soft palate (diagramatic): *a b*, incision after staphylorrhaphy for dividing the muscles arising from the hamular process (levator palati and palato-pharyngeus) [Esmarch].

Billroth has, with good results, broken off the lower portion of the internal pterygoid plate above the hamular process, so that the latter becomes movable and may be pushed, together with the portion of muscle that is attached to it, toward the median line.

As has been said, it is advisable, in the case of children in their first year, to divide the operation into two stages (see page 400). Wolff thinks that all the above-mentioned operative measures for relaxing the line of suture in the soft palate proceed from false premises, and he no longer makes use of them. According to him, the soft palate is best relaxed by separating the soft parts of the hard palate from the bone in every case of suture of the soft palate, just as in uranoplasty. He also recommends uniting the halves of the uvula by fine sutures not only on their anterior but also upon their posterior surface, and then suturing together from this posterior surface the uppermost portions of the halves of the posterior palatine arches. In this way the sutures hold better and the functional result is said to be more satis-

factory, inasmuch as the function of the palato-pharyngei muscles is restored.

The after-treatment is the same as in uranoplasty. Speaking must be prohibited as far as possible. The nourishment of the patient is of the greatest consequence, and is given, if necessary, through a stomach tube. In introducing the tube the line of suture should be protected from injury by a rubber plate (Ehrmann). The sutures are removed in from three to seven days. Silver wire may be allowed to remain from ten to twelve days. Should the line of suture open again in part, closure of the gap may still be secured by secondary suture or by use of the nitrate-of-silver stick. If staphylorrhaphy fails entirely, some time must elapse before a second operation—three months, six months, or a year, according to the age of the patient. Regarding other measures in the after-treatment, instruction in speaking, for instance, and the use of India-rubber obturators, the reader is referred to page 400.

§ 64. **Injuries of the Palate, the Tonsils, and the Pharynx.**—Injuries to the palate are, as a rule, rare, gunshot and punctured wounds being most frequent. Punctured wounds of the palate occasionally occur when children fall to the ground with anything sharp in the mouth. In gunshot wounds inflicted by suicides shooting into the mouth, the ball sometimes penetrates the hard palate and enters the nasal cavity or the superior maxilla. Hæmorrhage from injury to the palate may be severe. The inflammatory reaction is usually not very great, being most marked after gunshot wounds. After perforation of the hard palate, especially when followed by suppurative periostitis and necrosis of the bone, defects result which are attended with the functional disturbances that have been described above.

Injuries of the pharynx and the tonsils are also rare. Considerable hæmorrhage occurs, especially in case of injury to the ascending pharyngeal artery, which, as is known, is a branch of the external carotid and passes upward, at first between the latter and the internal carotid, and then in the angle between the posterior wall of the pharynx and the inner surface of the internal pterygoid muscle to the base of the skull. In gunshot and punctured wounds of the tonsils the internal carotid artery lying behind them may be injured, which has happened also, in exceptional cases, during the removal of hypertrophied tonsils, particularly by a galvano-cautery loop. Finally, injuries to the pharynx from punctured or gunshot wounds of the neck or the region of the hyoid bone are to be mentioned. It is of practical importance that after injuries to the pharynx œdematous swellings easily ensue through which swallowing and breathing are made difficult. If this œdematous swelling involves the epiglottis, the aryteno-epiglottidean folds, and the upper

part of the larynx, the difficulty in breathing may become such as to make tracheotomy necessary. In such cases the swelling of the epiglottis and its surroundings may be easily felt with the finger or seen by laryngoscopic examination.

In rare cases a progressive phlegmonous inflammation results from injuries to the pharynx which may extend down into the posterior mediastinum and may cause death from suppurative mediastinitis.

The treatment of injuries of the palate, tonsils, and pharynx consists, above all, in arresting the hæmorrhage, which, as a rule, stops either spontaneously or by the use of small pieces of ice in the mouth, by compression, or the application of the thermo-cautery or galvano-cautery. In case of hæmorrhage from the soft palate, the suture checks it sufficiently. If the internal carotid is injured behind the tonsils, the common carotid should be tied in the neck on the inner side of the sterno-mastoid muscle. The ascending pharyngeal artery is best found by means of an incision parallel to the posterior border of the ramus of the lower jaw from below the tip of the ear to the angle of the jaw.

All wounds that are suited for it are sutured, especially those of the soft palate. Wounds of the hard and soft palate that are not sutured frequently close up if the granulations between the edges of the wound are stimulated by frequent cauterization and premature skinning over of the wound is prevented.

The use of antiseptic washes and inhalations constitutes the best after-treatment of injuries to the palate and pharynx. In case of threatening œdema of the glottis, with corresponding disturbance in breathing, ice should be used internally and externally; and if the dyspnœa increases, tracheotomy should be performed as soon as possible.

If swallowing is impeded as the result of œdematous swelling of the palate and throat, the patient must be fed through a stomach tube.

With reference to the treatment of inflammatory processes following injuries the reader is referred to § 66, page 407 ff.

Any resulting defects in the palate can be closed by uranoplasty and staphylorrhaphy, or by means of obturators (see page 400 ff).

§ 65. **Foreign Bodies in the Throat and Pharynx** almost always come from food. Bits of bone, fish bones, and the like are the most common. It sometimes happens in the case of people who swallow large morsels of food that has been hastily and insufficiently masticated, that these morsels stick in the pharynx and become so wedged in that, owing to their size, they can be forced neither upward nor downward. In one such case I saw a workman choke to death who was hastily eating a German beefsteak. It was found at the autopsy that the large piece of meat which was wedged in the pharynx also stuck fast in the entrance to the larynx. False teeth also may become wedged in the throat and occasion threatening symptoms. If foreign bodies remain for

some time in the throat the patient may die in consequence of loss of blood from an injured artery, the superior laryngeal or the ascending pharyngeal, for instance; or from pneumonia, in case, for example, the foreign body prevents the epiglottis from closing the entrance into the larynx.

Foreign bodies in the throat can usually be seen, especially if the tongue is depressed with a spatula while the mouth is opened wide and the patient sounds the letter *r* or swallows. The presence of smaller bodies in the upper and lower parts of the pharynx may be demonstrated by posterior rhinoscopy, by laryngoscopy, or simply by palpation with the finger.

The removal of foreign bodies from the throat and pharynx is accomplished by means of curved forceps. If the foreign body can be felt from the outside and can not be reached from within the mouth, it is to be removed by an incision in the neck. If, owing to the size of the body, there is danger of asphyxia, as in the case of large morsels of food, the finger is quickly introduced into the mouth and the body is drawn out with the forefinger bent like a hook. If the foreign body is situated deep down in the pharynx or œsophagus, it may be pushed down into the stomach by means of an œsophageal bougie (see also § 109). If the body is in the larynx, immediate tracheotomy may be necessary. If delay is dangerous, the object is most quickly attained in the case of adults by piercing the crico-thyroid membrane, dividing skin and ligament at one stroke in the median line (see § 106, tracheotomy or laryngotomy). In case of children the cricoid cartilage must also be divided.

§ 66. **Inflammation of the Soft Palate, the Pharynx, and the Tonsils.**—The abundance of lymphadenoid tissue in the mucous membrane of the soft palate and pharynx is of special significance in connection with inflammation of these parts. This lymphadenoid tissue is found in the form of small nodular areas in the mucous membrane and is collected in especially large amounts in the tonsils. According to Stöhr, leucocytes constantly pass from this lymphadenoid tissue and collect on the surface of the mucous membrane.

Acute catarrhal inflammation of the soft palate, the palatine arches, and the tonsils—so-called angina—arises partly from local irritation following traumatisms or colds and in connection with similar affections of the nose and pharynx, and in part as a symptom in the course of systemic diseases (measles, scarlet fever, small-pox, etc.). The ordinary acute catarrhal angina is characterized by hyperæmia, swelling, and increased secretion of mucus or of a muco-purulent material which covers the surface of the mucous membrane as a whitish, more or less circumscribed or diffuse coating. There is sometimes a formation of small vesicles (angina vesiculosa), which may burst and cause corresponding small losses of substance or ulcers.

Acute catarrhal inflammation of the pharynx (pharyngitis catarrhalis acuta) is found, as a rule, in connection with the above-mentioned acute catarrhal inflammation of the soft palate, the tonsils, and the nose.

Among adults, smokers and drinkers suffer most frequently from acute or subacute exacerbations of an already existing chronic pharyngitis. Acute pharyngitis is also characterized by hyperæmia and swelling of the mucous membrane and by an increased muco-purulent secretion.

The symptoms of acute pharyngitis are frequent clearing of the throat, slight difficulty in swallowing, and pain. As a consequence of increased reflex irritability of the pharynx, nausea and even vomiting may occur, especially in the morning. Acute pharyngitis can easily extend through the Eustachian tube and give rise to catarrh of the middle ear.

In acute inflammation of the soft palate and pharynx the tonsils are always involved, and often to a marked degree. Inflammation of the tonsils (tonsillitis, amygdalitis, angina tonsillaris) is very common, since, owing to their exposed position, their follicular formation, and their numerous crypts, they afford an excellent soil for the action of the most varied injurious influences, especially for the cultivation of microbes. From the last consideration it is easy to understand that acute inflammation of the tonsils may occasionally cause death from a spreading phlegmon and septicæmia.

Acute tonsillitis is sometimes a superficial and sometimes a more deeply seated inflammation. In the latter case the swelling of the tonsils is especially pronounced. The surface of the tonsils is covered with a mucous or muco-purulent secretion, and plugs consisting of leucocytes and desquamated epithelium are often visible in the crypts (follicular tonsillitis).

Other symptoms of tonsillitis are painful and difficult swallowing and more or less pronounced fever.

We have already mentioned (see page 365), in connection with diseases of the mucous membrane of the mouth, the temporary swelling and hyperæmia of the mucous membrane of the throat, observed especially in neurasthenic individuals (vasomotor neuroses).

Occasionally benign (non-dyscrasic) ulcerations are found on both palatine arches which are usually but slightly painful and are covered with a grayish-white coating. Bujwid found in Heryng's cases the streptococcus monomorphus and variegatus as the probable exciter of the inflammation.

Among the acute inflammations of the soft palate, the tonsils, and the pharynx, erysipelas should be mentioned, which appears upon the parts named in consequence of slight abrasions of the mucous membrane, or from extension of erysipelas of the face or the nose to the soft palate and pharynx. Erysipelas of the pharynx may extend down into the larynx and even into the lungs, where the so-called erysipelatous or creeping pneumonia ensues (see the author's treatise

upon erysipelas, Deutsche Chirurgie, Lieferung 5). From œdema of the glottis—that is, very pronounced swelling of the entrance to the larynx, especially in the vicinity of the glottis, the epiglottis, and the aryteno-epiglottidean folds—death from asphyxia may result if tracheotomy is not promptly performed.

What was said above (§ 56, page 367) concerning erysipelas of the buccal cavity applies substantially to erysipelas of the pharynx. The latter is more frequently secondary, following erysipelas of the head or the face. The reverse of this—i. e., primary erysipelas of the pharynx spreading to the skin of the face and head—is rarer. Lennander has recently reported some typical cases of primary erysipelas of the pharynx with secondary appearance of the disease on the face. Primary erysipelas of the pharynx runs its course with chills, fever, and intense hyperæmia of the parts, difficulty in swallowing, "sore throat," swelling of the glands at the angle of the jaw, and possibly earache and suppurative inflammation of the middle ear. Tracheotomy is, as has been said, sometimes necessary. In cases that end fatally the autopsy has revealed meningitis, pleurisy, pneumonia, and peritonitis.

The treatment of the catarrhal and erysipelatous inflammations of the palate, pharynx, and tonsils that have been mentioned consists in the use of antiseptic washes, small pieces of ice in the mouth, and wet compresses or an ice-bag around the neck. In addition, demulcent drinks are given, as well as chlorate of potash internally. Antiseptic inhalations are also valuable.

The treatment of erysipelas of the pharynx is essentially the same as that of erysipelas of the mucous membrane of the mouth (see page 367). Careful attention must be paid to possible complications—such as otitis media, suppuration, etc.

When there is more pronounced swelling in connection with erysipelas, multiple scarifications of the mucous membrane with a pointed knife do good service. In case of dyspnœa resulting from œdema of the glottis, tracheotomy is necessary.

In all cases in which inflammation of the tonsils frequently recurs the removal of the tonsils by tonsillotomy is necessary.

Phlegmonous processes and abscesses occur most commonly in the tonsils, but are also found in the soft palate and in the pharynx, after injuries, for instance. The swelling can be very marked and cause dyspnœa by obstructing the entrance to the larynx. Abscess of the tonsils is almost always unilateral, and may be made up at first of several small foci of pus which may separately break through externally. More frequently, however, the larger characteristic abscesses of the

tonsils, with bulging of the anterior pillar, occur, which must be opened through the latter by the point of a knife. Not infrequently considerable destruction of tonsillar tissue takes place as the result of suppuration and gangrene. Gangrenous processes in the soft palate, tonsils, and pharynx appear most commonly in connection with diphtheria, variola, dysentery, and typhoid fever.

Other symptoms of phlegmonous inflammation of the palate and pharynx are, above all, fever and difficulty in swallowing and breathing in consequence of the swelling. Inflammatory lockjaw also frequently attends suppurative inflammation of the tonsils and their neighbourhood, so that the patient can scarcely open his mouth sufficiently to allow an incision to be made in the swollen parts.

The treatment of suppurative inflammation of the soft palate, the pharynx, and the tonsils is at first antiphlogistic (ice within and outside the throat, antiseptic washes, etc.). Helbing recommends rubbing in three or four drops of croton oil beneath the angle of the lower jaw in the direction of the larynx. In case of marked swelling, incisions should be made early, even if the presence of pus can not be made out. Abscesses of the tonsils are best opened by sticking a pointed scalpel through the soft palate into the tonsil and then making a vertical incision downward. Injury to the internal carotid is impossible unless one cuts too far outward. The opening made by the incision must not be allowed to close too early, and if the edges become adherent in the course of the next few days they are separated by a probe and cauterized with the nitrate-of-silver stick. If inflammatory lockjaw is present it may be necessary to first open the mouth under anæsthesia by means of a mouth gag. In such cases care must be taken that the pus is not aspirated into the lungs. After the pus is evacuated great relief usually follows, the fever falls rapidly, and the patient is, as a rule, well in a few days if antiseptic gargles are diligently used and the retention of pus is prevented by keeping the incision open.

In case of very large abscesses in the pharynx—retropharyngeal abscesses, for instance, resulting from tubercular caries of the cervical vertebræ—much care must be taken, particularly with children, that the pus is not aspirated, causing asphyxia or septic or tubercular inflammation of the lungs. The best way in such cases is to make a small incision at first and allow the patient to gradually cough the pus out. Only after it has been discharged in this way should the opening be enlarged to a sufficient size. It is much better and easier to open retropharyngeal abscesses from the outside (H. Buckhardt, Chiene, Sacchi). For a more exact description of retropharyngeal abscesses see § 94.

If acute abscesses of the pharynx have already begun to point externally or to burrow down the neck, the incision should, of course, be made from the outside (see § 94).

In all cases in which abscesses of the tonsils frequently recur, tonsillotomy (see pages 425–427) should be performed, in order to remove permanently the recesses that exist with their permanent collections of microbes.

Senator and others have recently described an "acute infectious phlegmon of the pharynx" as an infectious disease *sui generis*, which is of considerable interest. It is an acute febrile disease which runs its course with only a moderate rise of temperature; "sore throat," and particularly difficulty in swallowing, appear at an early stage. Then follow laryngeal symptoms, consisting of more or less hoarseness and dyspnœa, and finally unconsciousness and death, without important changes in the internal organs. There is found post-mortem a diffuse suppurative inflammation in the deeper tissues of the mucous membrane of the pharynx, which spreads to the larynx and the glands and involves other organs secondarily (enlarged spleen, nephritis, gastritis, eruptions). The disease usually attacks persons who were before perfectly well. An etiological factor is usually not demonstrable, the mucous membrane of the pharynx having, as a rule, been neither injured nor otherwise diseased beforehand. It is essentially a septic phlegmon, and I am inclined to believe that the infection proceeds from some small wound or superficial erosion of the mucous membrane of the pharynx or from the tonsils.

The prognosis of this acute infectious phlegmon of the pharynx is, so far as present experience goes, to be designated as extremely unfavourable. The disease is usually first recognised when the infection has already advanced too far. The treatment is essentially symptomatic (antiphlogistic remedies, incisions, etc.).

§ 67. **Diphtheria.**—Diphtheria of the throat (from διφθέρα, leather, skin) is a local infectious disease caused by Löffler's diphtheria bacillus, and either goes on to recovery, the whitish-gray diphtheritic membrane being cast off, or ends fatally, partly from extension of the disease to the larynx and the bronchi, partly from systemic intoxication by the toxines formed by the bacilli, and in many cases from paralysis of the heart, due to infectious myocarditis.

Typical diphtheria of the throat begins, as a rule, with the formation of small, circular, grayish-white patches upon the reddened and swollen mucous membrane. These whitish-gray areas gradually increase in thickness and extent, and finally coalesce, forming membranes which may cover a large portion of the soft palate, the tonsils, and the

pharynx. The grayish-white or yellowish-white, or sometimes, in consequence of hæmorrhages, brownish or blackish membranes, consist of portions of necrotic mucous membrane containing microbes, fibrinous exudation, and leucocytes. These layers of dead tissue are gradually cast off, and healing of the resulting defect in the tissue follows, or a second diphtheritic membrane appears. The depth and extent of the necrosis are very variable. Sometimes the epithelium only, or the superficial layer of the mucous membrane, is attacked (diphtheritis superficialis); or, again, the entire thickness of the mucous membrane, with a portion of the submucosa, dies (diphtheritis profunda). The mild, superficial forms of diphtheria are also called membranous croup. The latter is by certain authors still strictly distinguished from diphtheria, but in our opinion, which is at present the one most generally accepted, the distinction between diphtheria and membranous croup is simply one of degree, both diseases being in their nature the same. Membranous croup is diphtheria which attacks only the superficial layers of the mucous membrane. According to recent investigation by Heubner, there exists no anatomical distinction between diphtheria and membranous croup.

FIG. 244.—Croupous pseudo-membrane (*B*) upon the mucous membrane (*Sch*) consisting of a network of fibrin permeated with leucocytes. × 150.

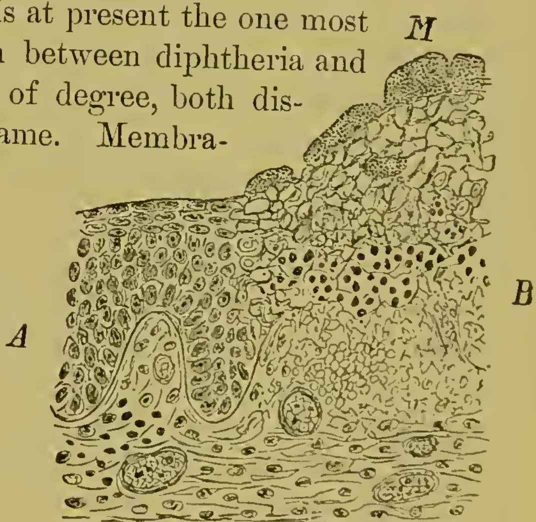


FIG. 245.—Section through a diphtheritic uvula at the edge of normal tissue: *A*, normal epithelium and normal submucous tissue; *B*, superficial and deep connective tissue permeated with fibrin, leucocytes, and red corpuscles; *M*, masses of bacteria. × 120.

Both inflammations, membranous croup and diphtheria, are characterized by the formation of an inflammatory product, consisting of fibrin and cells, which appears in the form of a membrane adhering lightly to the surface of the mucosa. In membranous croup (Fig. 244) the membrane lies *upon* the mucous membrane, whereas in diphtheria the exudation is found also *in* the mucous membrane, and the latter is soon more or less destroyed (Fig. 245). In the formation of these pseudo-membranes the "fibrinoid" degeneration of

the epithelium plays, together with the fibrinous exudation, according to Baumgarten, a prominent part. In membranous croup there is only fibrinous degeneration of the epithelium, but in diphtheria this process involves the connective tissue as well. The local death of tissue caused by diphtheritic inflammation is, according to Cohnheim and Weigert, a coagulation necrosis—that is, death of the tissues or cells from coagulating lymph which permeates the tissues that are involved and makes its way into the cells. The croupous and diphtheritic membranes are cast off after a certain time as the proliferating epithelium underneath pushes the portions of membrane before it until they fall off (Heubner). In severe cases the membrane is cast off *in toto*. In extensive croupous inflammation of the bronchi the latter are sometimes completely filled with a fibrinous exudate, so that the patients cough up branching casts of the bronchial tubes (Fig. 246). Membranous croup can be developed experimentally in the trachea of the rabbit, for example, by the injection of liquor ammonii causticus. The animals usually die in two, three, or four days with the symptoms of asphyxia.

Fig. 246.—Fibrinous cast of the bronchi in bronchial croup.

There exists no anatomical distinction between this experimental croup and epidemic diphtheria (Middeldorpf, Goldmann). The fauces and trachea are most frequently attacked by croupous and diphtheritic inflammation, less frequently the mucous membrane of the bladder and intestine. Diphtheria is also occasionally found on the skin, following, for example, infection of excoriations of the skin or of wounds, and it is especially common in the neighbourhood of mucous membranes, in the vicinity of the larynx, for instance, after tracheotomy, or about the female genitals, the rectum, etc. Diphtheria proper is an infectious disease caused by a specific bacillus whose existence was first demonstrated by Löffler. It is strictly to be distinguished from all those pathological processes which are likewise connected with the formation of croupous or diphtheritic changes in the mucous membranes and are not distinguishable anatomically from diphtheria proper (pseudo-diphtheria, so called). Heubner produced, by temporary interruption of the circulation of the blood, an artificial local pseudo-diphtheria of this kind upon the inner wall of the bladder, which was not transferable to

animals by inoculation like diphtheria proper. In true diphtheria there arises, as the result of the poisonous metabolic products of the bacilli, a severe systemic intoxication, with fever. Its degree is very variable, and it often leads to speedy death, especially from degeneration of the heart muscle.

Etiology of Diphtheria.—Löffler's Diphtheria Bacillus.—Löffler was the first to demonstrate the presence, in diphtheria in the human body, of a constant species of bacteria (Fig. 247), to cultivate it artificially, and to inoculate it upon animals. He did not succeed, it is true, in producing true diphtheria in the latter, but was able to demonstrate that these bacilli were of a pronounced infectious character. Zarniko, Babes, Kolisko, Fränkel, and others confirmed Löffler's statements, and Roux, Yersin, Tangl, and others have also successfully inoculated animals with Löffler's bacillus and observed the symptoms peculiar to diphtheria in man, including the development of local diphtheritic processes and paralysis in consequence of the systemic intoxication. From these facts we are justified in the assumption that Löffler's bacillus is really the exciting cause of diphtheria.

The diphtheria bacillus has the form of a small rod about as long as the tubercle bacillus but about twice as broad, and its ends are usually rounded (Fig. 247). It varies greatly in form, however. Many have the form of a rod with a knobby thickening at each end, while others break up into several fragments by transverse division (involution forms). The bacilli are found only in the diphtheritic pseudomembranes, nowhere else in the body. The severe general symptoms that attend diphtheria are therefore caused

Fig. 247.—Diphtheria bacilli, × 1200: *a*, young bacilli from a fresh culture; *b*, involution forms (Löffler).

Fig 248.—Diphtheria bacilli: culture on coagulated blood serum. × 1000.

by the extremely poisonous products of their metabolism. Opinion is divided with reference to the nature of the toxines of the diphtheria bacilli. The general assumption is that they are albuminous bodies, toxalbumins according to Brieger and Fränkel, diastases according to Roux and Yersin, nucleins according to Gamaleia. They sometimes arise from decomposition of the albuminous bodies contained in food, or the microbes form them within themselves or by synthesis of simple bodies (Guinochet, Straus). The toxines of diphtheria bacilli are marked by a certain instability. They are decomposed by heat and fermentation (pepsin, pancreatin) and pass without injury

through the alimentary canal (Gamaleia). They are also considerably weakened by antipyrine (Vianna). From the simultaneous presence of streptococci and staphylococci mixed infections result.

The bacilli are facultative anaerobic, and incapable of active movements. They grow in temperatures from 20° to 42° C. in gelatin or other nutritive media which must always be made somewhat alkaline, and particularly well upon Löffler's blood serum (three parts blood serum of cattle or sheep, one part beef bouillon, one per cent peptone, one half of one per cent common salt, and one per cent grape sugar) and glycerin agar. Upon Löffler's blood serum there forms in about two days, in an oven with a temperature of 37° C., a thick, whitish, shining covering. On glycerin agar there forms at hatching temperature in from twenty-four to forty-eight hours flat, grayish-white, shining colonies, with a flat border about the size of a millet seed (Fig. 249). The cultures grow slowly at first upon agar, but the second generation more luxuriantly, because the bacilli have accustomed themselves to the nutritive medium which was at first but little suited to them. The virulence, however, usually decreases at the same time. In stab cultures in gelatin small, whitish, globular colonies arise. On gelatin plates (22° to 24° C.) the colonies remain small and the glycerin is not liquefied. The bacillus grows upon potato if the surface is made alkaline. Milk is also a good nutritive medium. The bacilli perish at a temperature of 45° to 50° C. Spore formation has not yet been observed. The bacilli have, moreover, great powers of resistance. In dried pseudo-membranes they remain capable of development for three to four months. Roux and Yersin showed that cultures in serum remained alive and virulent, under ordinary circumstances, for five months, and further, that the cultures, if kept securely shut up and protected from the influence of air and light, retained their full virulence after thirteen months.

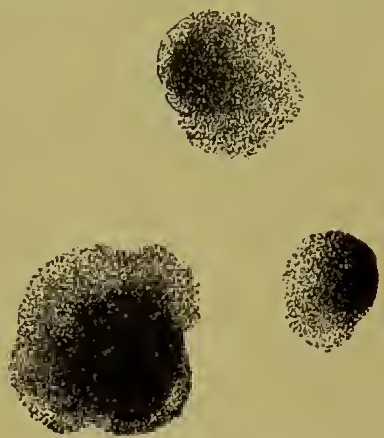


Fig. 249.—Diphtheria bacillus: colony on an agar plate twenty-four hours old. × 100.

Diphtheria bacilli are best stained with Löffler's alkaline methylene-blue solution, or by Gram's method (Roux and Yersin). Virulent diphtheria bacilli are scarcely ever found in the mucus of the mouth of healthy or otherwise diseased persons, but, according to Löffler and Hofmann, the very similar pseudo-diphtheria bacilli are frequently found. These are without pathogenic action and are, perhaps, to be looked upon as attenuated diphtheria bacilli.

Inoculation upon animals does not succeed easily. Guinea-pigs, rabbits, pigeons, and chickens are especially susceptible. Mice and rats resist very strongly. In rabbits, pigeons, etc., the cultures produce pseudo-membranes in the trachea, and sometimes severe constitutional symptoms, paralysis, etc. Guinea-pigs are most susceptible. They perish, even after subcutaneous inoculation, within a few days, from œdema, pleuritic effusions, etc., without the presence of bacilli in the inner organs being demonstrable (Roux, Yersin,

Brieger, C. Fränkel). Filtered cultures or the poisonous albuminous bodies isolated from the cultures (toxalbumins) cause severe symptoms of intoxication, which, however, often lead only very slowly to a fatal result.

Behring and Kitasato rendered animals artificially immune from diphtheria. This was accomplished, first, by use of sterilized cultures, according to C. Fränkel; second, by the addition of the trichloride of iodine to the cultures; third, by subcutaneous and intra-abdominal injection of pleuritic exudations, which frequently develop in diphtheritic animals; fourth, by injections of the trichloride of iodine very soon or a few hours after diphtheria infection. Finally, an increased power of resistance to diphtheria infection was imparted to animals by means of peroxide of hydrogen given a few days before the infection. C. Fränkel imparted to Guinea-pigs immunity from diphtheria in fourteen days by inoculation of a sterilized culture fluid which was heated for an hour at a temperature of 60° to 70° C. There were found in the culture fluid two kinds of substance, one being toxic, which is destroyed by heating to 55° to 60° C., and one that gives immunity. The animals treated by the methods of Behring and Kitasato are not only proof against infection from living diphtheria bacilli, but also against the injurious action of the poisonous products of their metabolism. This immunity may, however, be lost by repeated injection of considerable amounts of toxine, especially if it had not been thoroughly established. The insusceptibility to diphtheria infection thus artificially produced depends upon changes in the blood serum of the animals in question. Behring has therefore recommended the latter in the form of hypodermic injections for therapeutic experiments upon diphtheria in the human body (see page 422). No definite judgment can be given as yet with regard to the success of this method of treatment. Very favourable reports of the use of this treatment have been published of late, so that at all events the method deserves great consideration. The therapeutic serum is also to be recommended by way of prophylaxis to guard from infection those in the immediate neighbourhood of the patient (Behring, Roux, etc.).

The diphtheria bacillus is characterized by a varying degree of virulence. This explains why the course of the disease in single cases and in different epidemics is so variable. Diphtheria spreads by contagion. The membranes, sputum, and saliva that are coughed out are the real sources of infection. The bacilli in the mouth of a convalescent still remain alive for about three weeks, those in a dried condition in the thicker layers for three or four months, and those in a semi-dried condition for seven months. Playthings, eating and drinking utensils, kissing, etc., occasionally cause infection. In food, especially in milk, there is sometimes an ectogenous growth of diphtheria bacilli. From about the thirteenth year the individual tendency to diphtheria rapidly decreases. Mucous membranes of the throat which are often the seat of catarrh are best suited to the growth of the diphtheria bacilli.

To avoid the occurrence and spread of diphtheria so far as possible, strict isolation of the patient in every particular is necessary, together with thorough disinfection of all objects with which he comes in contact.

Besides the diphtheria bacilli, streptococci and staphylococci are very often, in fact almost always, present in diphtheria. These seem to be without sig-

nificance for the etiology of diphtheria as such, but they may occasion general septic infection (mixed infection—Beck, Kolisko, Paltauf, Barbier, and others). There is, according to Baginsky, a form of diphtheria which resembles true diphtheria clinically, but is not dangerous and ends in recovery. Löffler's bacillus is said to be absent here. Baginsky found only streptococci and staphylococci.

Aside from the true diphtheria bacillus, Löffler and others have also described a pseudo-diphtheria bacillus which differs little morphologically and biologically from the genuine diphtheria bacillus. It is somewhat shorter and thicker, grows more luxuriantly at 20° to 22° C. in bouillon, changes the reaction of bouillon more rapidly, forms upon serum a more yellowish covering, and does not thrive so well as the genuine diphtheria bacillus when deprived of air. When inoculated upon animals local symptoms are sometimes observed, but death never ensues (Roux, Yersin). Pseudo-diphtheria bacilli are found in the mouth in healthy individuals and in cases of simple angina. According to Roux and Yersin, certain relations may exist between the two kinds of bacilli. They were able to change genuine, very virulent diphtheria bacilli permanently by the action of a constant stream of air continued for several days, so that they acted like pseudo-diphtheria bacilli. On the other hand, they could restore to attenuated diphtheria bacilli their full virulence by simultaneous inoculation of erysipelas cocci, but not to the pseudo-diphtheria bacilli. The latest investigations seem to show that these two forms of bacilli are not different microbes but belong to the same species, the only difference being that of virulence (Löffler, Fränkel, and others). Escherich, on the other hand, regards the pseudo-diphtheria bacillus as a special variety.

The location of diphtheria in the throat is very variable, now appearing mainly on the velum palati and the uvula, and again more on the tonsils and the posterior wall of the pharynx. In severe cases all the parts named and the nasal cavity as well have thick diphtheritic coatings. Diphtheria very often travels downward, involving the epiglottis, larynx, and finally the lungs, where precisely the same fibrinous exudation forms, reaching into the smallest bronchi. The extension of diphtheria of the throat to the nose and larynx is always a very unfavourable sign. The tonsils are generally much affected, and very frequently it is here that the disease begins.

The parts in the vicinity of the throat and the nearest lymph glands are always involved in the diphtheritic process. If the cellular tissue of the neck and the lymph glands on both sides of the lower jaw, especially near the angle of the jaw, become very much swollen, death generally ensues as the result of systemic poisoning with the diphtheritic toxines.

The clinical course of diphtheria is very variable, according to the greater or less malignity of the individual epidemics and endemics. The above-described diphtheritic coatings upon the tonsils, on the soft

palate, spreading to the pharynx, the nasal cavity, the larynx, the trachea, and the bronchi, are more or less clearly marked. The involvement also of the neighbouring lymph glands and swelling of the cellular tissue in the submental region, particularly near the angle of the jaw and the ascending ramus, is more or less constant, as well as the rise of temperature and the symptoms referable to the nervous system, the kidneys, and other organs, due to the systemic poisoning.

The coating on the fauces is usually visible on the first or second day of the disease, unless it begins behind the pillars, in the upper naso-pharyngeal cavity, or in the depths of a tonsillar crypt.

The disturbances resulting from the local disease are difficulty in swallowing, salivation, and nasal speech, due to the fact that the swollen or paralyzed velum palati can not reach the posterior pharyngeal wall. Earache is also very common. Sometimes the local disturbances are slight or almost entirely absent, in which case patients, adults especially, attend to their business without a suspicion of their illness.

The constitutional manifestations of the disease are also very variable. They may, as in the cases last mentioned, be very slight, while other patients immediately show severe general symptoms with high continuous fever. Most cases lie between these types—that is, the fever gradually rises, as a rule, to from 40° to 41° C. (102° to 104° F.). Prostration, disturbances of digestion, albuminuria, etc., are common symptoms of diphtheria. The interference with respiration depends upon the amount of swelling or upon the involvement or non-involvement of the larynx.

The extension of diphtheria of the throat, especially to the larynx, the trachea, and the lungs, or to the nasal cavity, is one of the most important and most serious of its complications. Involvement of the Eustachian tube, the middle ear, the mouth, and the œsophagus occurs, and, in rare cases, even of the stomach.

Of other complications I will mention the gangrenous destruction of the tissues attacked by diphtheria, hæmorrhage, suppuration of the lymph glands behind the jaw, lobular and lobar pneumonia, endocarditis, myocarditis, albuminuria, diarrhœa, eruptions, and paralyses. Baginsky and others have seen in rare cases trismus and tetanus.

Diphtheritic paralysis most frequently attacks the muscles of the palate and pharynx, and, in consequence of this, disturbances in swallowing and speaking take place. Fluids usually escape through the nose, because the constrictor muscles of the pharynx do not carry them down to the œsophagus. The soft palate, hanging down in a flaccid condition, can not reach the posterior wall of the pharynx, and this occasions the same nasal tone as that attending defects in the palate

Besides this paralysis of the muscles of the palate and throat, paralysis of the organs of special sense also follows diphtheria, especially paralysis of the nerves of smell, taste, and sight, leading, it may be, to complete blindness and disturbances of accommodation. Paralysis of the muscles of the face and extremities also occurs. These symptoms usually appear during convalescence, a week or two after recovery begins. The prognosis of this paralysis is favourable, recovery usually following in a few weeks or months. In diphtheritic paralysis we have to do with a pronounced interstitial inflammation of the muscles that are involved, which can also be demonstrated in the muscular fibres themselves. There is also a slight interstitial inflammation of the nerves. The central nervous system is intact (Hochhaus).

Secondary diphtheria of the skin in cases of severe diphtheria of the throat is also of special interest. This is found only in those parts of the outer skin which have lost their epidermis, as in intertrigo and eczema of the inguinal fold and in wounds of the skin. In rare cases the reverse is true—that is, secondary diphtheria of the throat has been known to follow this primary diphtheria of the skin.

Finally, there appear in the course of diphtheria various forms of eruption, which are, for the most part, of serious prognostic significance. When diphtheria is attended with changes in the skin—e. g., with dark-red or bluish-green petechiæ, with erythema, or, what is less frequent, a papular eruption, with spreading ulcers arising from small hæmorrhagic, varicella-like vesicles (Riehl), etc.—it almost always ends fatally. Inasmuch as streptococci so often appear in diphtheritic foci, it is easy to understand why diphtheria is sometimes complicated by erysipelas of the mucous membrane, and especially of the skin (Leyden, Renvers).

With reference to other forms of diphtheria, complicating scarlet fever and measles, for example, the reader is referred to text-books on internal medicine.

If diphtheria ends in recovery the necrotic tissue is cast off, the infiltration is absorbed, and the defect thus made is healed with a corresponding cicatrix. The layers of exudate are gradually displaced by the succeeding healthy epithelium. If a diphtheritic membrane comes away *in toto*, this is due to the elasticity of the coagulated substance. Cicatrices are left especially after deep and extensive necrosis.

Death results in diphtheria either from systemic poisoning or from local processes, particularly spreading of the disease to the larynx and the lungs, from progressive sloughing of the tissues, from disease of the kidneys, from hæmorrhage into the brain and its membranes with corresponding paralysis, from collapse due to extreme anæmia, or from

paralysis of the heart in consequence of infectious myocarditis. Anatomically, diphtheritic myocarditis is partly a rapid fatty degeneration of the muscular fibres and partly an interstitial or interfibrillar myositis. By means of the sphygmomanometric method the degree or prognosis of the heart complication may be determined during the life of the patient more exactly and earlier than by ordinary clinical observation (Friedemann).

It is during convalescence after a severe attack of diphtheria that paralysis of the heart in consequence of infectious myocarditis is particularly to be feared, and many a child who is supposed to be saved dies suddenly in from the fourth to the sixth week.

The prognosis of diphtheria attended with sloughing of the tissues is very unfavourable, almost hopeless in fact, and this explains why one never, or almost never, sees defects in the soft palate caused by diphtheritic gangrene.

The Treatment of Diphtheria.—Many remedies and methods of treatment have been recommended, and yet no one of them is altogether satisfactory. Mild cases take care of themselves, and in severer cases the chief danger—that of general intoxication and the spreading of the disease to the larynx and the lungs—is usually not to be prevented by any form of treatment. Physicians assert that they have met with great success by the use of this or that method of treatment; but how often are cases diagnosticated as diphtheria which are diphtheria anatomically, to be sure, but not bacteriologically! For this reason therapeutic statistics regarding the disease, aside from the varying malignity of individual epidemics, are very untrustworthy.

The treatment of diphtheria consists of suitable local measures and a symptomatic treatment of the systemic intoxication.

I am especially opposed to every method that tends to irritate the throat. All mechanical therapeutic measures from which injuries to the throat may result I consider thoroughly objectionable, the more since diphtheria develops only upon mucous membrane that is wounded, as Roux and Yersin were the first to demonstrate. Each diphtheritic focus should at the beginning be destroyed as soon as possible by the cautery, with the aid, it may be, of an anæsthetic. Hagedorn, Bloebaum, and others have also obtained favourable results from this method. An ice bag is laid about the throat, special care is given to cleansing the mouth with disinfecting mouth and throat washes, and vapours of boric acid, carbolic acid, resorcin, etc., are inhaled. The air of the sick-room must likewise be frequently changed and disinfected, which may be accomplished very simply by hanging up sheets which have been dipped in a three-per-cent solution of carbolic acid. Inter-

nally, chlorate of potash is given cautiously, and fluids of a strengthening nature. Fever, when excessive, is reduced by cold-water treatment (cold packs or cold baths at a temperature of 18° to 20° R. [75° to 80° F.] or cold shower baths) or by antipyretics. Other complications are treated in the usual way. If there are symptoms of stenosis of the larynx, tracheotomy, which, if performed in the right way, can do no harm but may be very useful, should be undertaken early enough (see § 106, Technique of Tracheotomy).

With reference to intubation in diphtheritic stenosis of the larynx, first recommended by American physicians, the reader is referred to § 106. This consists in inserting a small tube into the larynx from within the mouth. I will only remark here that the results from intubation of the larynx for diphtheritic stenosis are, in general, not more favourable than those from tracheotomy, and that the after-treatment in the former is more difficult. In the Leipsic hospital for children we have had very satisfactory results from the use of intubation, and it is generally used, in case of stenosis of the larynx, in place of tracheotomy. Children treated by intubation can be very well cared for in a hospital, but in private practice one is likely to meet with great difficulties. I think, in general, that intubation is of the greatest importance in all those cases of asphyxia in which, for practical reasons—e. g., want of necessary instruments, assistance, etc.—tracheotomy is impossible.

Of the other methods of treating diphtheria, I regard cauterization with lunar caustic in solid form or in solution, or with chromic or hydrochloric acid, as inadvisable, inasmuch as the focus of infection is too greatly irritated.

It would be very advantageous if we possessed a means of dissolving the diphtheritic membranes, but we have no such. The most effective agents in this direction are limewater (1 : 2–4 aqua), lactic acid (1 : 15–20 aqua), and one-half- to one-per-cent lysol. These remedies are accordingly much used for gargling, inhalation, and painting. Lysol is very efficient in dissolving mucus. The insufflation of alum or tannin, the application of liquor ferri chloridi or citric acid, painting with tincture of iodine, glycerin-bichloride solution (20 to 1), have been strongly recommended. Bennert recommends the use of a solution of 1 part bichloride, 5 parts tartaric acid, and 1,000 water. Swabs are soaked with this mixture, the diphtheritic membrane is briskly rubbed away, and the bleeding surface is then treated in the same way again. In from six to twelve hours the same thing is repeated, if necessary. Levy and Knopf paint the diseased mucous membrane with a mixture of papayotin, 10·0 ; acid. carbol. pur. liquid., 5·0 ; aq. dest., 100·0 (to be

shaken before using). This is applied every ten minutes for the first two hours, and then—during the night as well—every two hours. Löffler recommends the following solutions to be applied on cotton every three or four hours during the first few days, and afterward less often: Alcohol 60·0, toluene 36, liq. ferri chloridi 4; moreover, the same solution with 10·0 menthol, or, finally, alcohol 60·0, toluene 36, with four grammes of two- to three-per-cent creolin, or four grammes of two- to three-per-cent metacreosote. The external and internal treatment of diphtheria with turpentine, which was for a time much used, seems at present to have been abandoned. Nepveu recommends spraying the throat with bichloride (one tablespoonful of a 1-to-1,000 solution to a glass of water) and a single injection of a 1-to-500 solution of bichloride into the tonsils and into the glands under the jaw by means of a hypodermic syringe.

E. Hoadley strongly recommends, as the result of a large experience, tincture of myrrh in the following form: 5·0 chlorate of potash; 15·0 tinct. myrrhæ; 5 drops carbolic acid; 20·0 mel despumat.; aq. dest., q. s., ad 150·0; fifteen drops every half hour. The solution serves also for inhalation.

Andeer, Leblond, Baudier, and others make use of a ten-per-cent resorcin-glycerin solution, which is applied with a brush every hour during the day and every two hours at night, combined with a continuous spray of a five-per-cent aqueous solution of resorcin.

Treatment of the systemic intoxication by a strengthening diet, a small stomach tube being introduced, if necessary, through the nose or mouth, is of the greatest importance. Stimulants and small doses of morphine are also to be recommended.

As regards the treatment of diphtheria with Behring's serum, it may be said in the first place that this has already been used with success in a large number of cases, but that it must be tried for a long time yet before a judgment *pro* or *contra* will be possible. This serum can be had in three different strengths, and is obtained from immunized horses. In every case the whole dose of ten cubic centimetres is injected beneath the skin of the abdomen with aseptic precautions. I have never observed any really harmful results from its use; an urticaria-like eruption sometimes appears. The mortality of diphtheria has at least been somewhat diminished by the use of the serum (Heubner). It has also been extensively used in the way of prophylaxis to protect those who come in contact with the patient. Aronson's serum has also proved efficacious, although here also a definite judgment is impossible. The value of Klebs's antidiphtherin is uncertain.

§ 68. **Chronic Inflammations of the Palate, Pharynx, and Tonsils.**—The chronic catarrhal inflammations of the soft palate and the pharynx (pharyngitis chronica) are very often the result of frequent previous acute inflammations, which are so common with smokers and alcoholics, with preachers

who are obliged to speak aloud a great deal, and also with persons who are exposed to dust during their work. The secretion in chronic inflammation of the palate and pharynx is, as a rule, muco-purulent or entirely purulent, and often dries in the form of dirty-green, offensively smelling crusts in the pharynx. The secretion is often very slight and the throat is noticeably dry. The mucous membrane is reddened and the tonsils are enlarged so that they protrude out of their niches. According to the condition of the mucous membrane in chronic catarrh of the throat, two distinct forms are distinguished, as in chronic rhinitis: 1, a hypertrophic or follicular pharyngitis; and 2, atrophic pharyngitis.

In the first form of chronic pharyngitis the mucous membrane is thickened and hypertrophied, and often has papillary or nodular excrescences. The hyperplasia is sometimes follicular—that is, it is caused by abnormal growth of the lymphadenoid tissue. This follicular form is also found especially in the neighbourhood of the so-called pharyngeal tonsil, in the naso-pharynx (see Fig. 165, page 267). The abnormal hyperplastic adenoid tissue can here attain such a size that the nasal meatuses and Eustachian tubes become closed (see also Fig. 253, page 434, New Formations of the Naso-pharynx). In other cases, instead of follicular hyperplasia there is principally a proliferation of the connective tissue which is permeated with leucocytes. The resulting thickening of the mucous membrane and of the subjacent parts is particularly noticeable on the uvula, so that it hangs down upon the tongue and is much enlarged. Visceral changes are often present, especially in the stomach, liver, kidneys, and heart.

In the second or atrophic form of chronic pharyngitis the mucous membrane is smooth and thinned.

The separate forms very often merge into one another, as in chronic rhinitis, and hypertrophic and atrophic areas are found in the same individual. Atrophic pharyngitis usually results from the hypertrophic form.

Ulceration and accumulation of secretion in the mucous glands, in the form of small granular spots, are very common symptoms of chronic pharyngitis.

The tonsils become hypertrophied in consequence of chronic inflammation, and may so increase in size as to protrude from their niches and, in severe cases, to meet in the median line. The disturbances arising from hypertrophied tonsils (tonsillitis hyperplastica chronica) are always considerable. The development of children is often affected, in extreme cases, in consequence of respiratory disturbances, due to an insufficient supply of oxygen to the lungs, and the removal of the tonsils is always attended by the most favourable results. Warren, Phocas, and others have asserted—rightly, as I believe—that children with hypertrophy of the tonsils and abnormal adenoid growths of the naso-pharynx in consequence of dyspnœa very easily contract deformity of the chest, especially pectus carinatum, the more so since rhachitis generally exists at the same time. All persons who have hypertrophied tonsils are obliged to sleep at night with open mouth, and snore. At times also, in case of very marked hypertrophy of the tonsils, sleep may be disturbed by attacks of suffocation. Hypertrophied tonsils strongly predispose to acute inflammation because microbes easily find lodging places in their crypts.

Other symptoms attending chronic pharyngitis and tonsillitis are the necessity of clearing the throat frequently and coughing. Especially in the morning the mucus that has dried during the night has to be removed by clearing the throat, coughing, and retching. Vomiting not infrequently occurs at the same time ("morning vomit" of chronic pharyngitis and tonsillitis). The odour from the mouth in consequence of the decomposed secretions from the tonsils is often marked. The patients themselves are most disagreeably sensible of this bad odour. As a result of interference with breathing or of the cough, a tendency to emphysema finally results. The voice is almost always changed in hypertrophy of the tonsils; the patient is often hoarse and speaks as though he had a lump in his throat. Hypertrophied tonsils may finally give rise to different reflex neuroses, such as œsophagismus, neuralgia, epileptiform attacks, etc. It is a well-known fact that hypertrophied tonsils form a favourable soil for the different varieties of bacteria, and I have no doubt that they sometimes serve as a point of entrance for metastatic inflammatory and suppurative processes, such as suppurative osteomyelitis and periostitis.

The prognosis of chronic pharyngitis is, generally speaking, favourable if the patients are brought under early treatment and the injurious influences that are at work cease. It is often very obstinate, however, especially in the later stages. This is particularly the case, of course, if there are complicating internal diseases.

Atrophic processes develop in the tonsils, also in the later stages of chronic pharyngitis, especially atrophic pharyngitis, so that the tonsils become abnormally small in consequence of shrinkage of the lymphadenoid tissue.

Cysts with yellowish-white contents are sometimes found in the crypts of atrophic tonsils. From calcification of these contents, smooth or more or less rough concretions may result. The latter are formed also by the calcification of plugs of epithelial cells and leucocytes in the crypts of the tonsils. They are from the size of a millet seed to that of a bean, seldom larger.

The treatment of chronic pharyngitis and tonsillitis of the hypertrophic form consists chiefly in the use of the galvano-cautery and in energetic cauterization with nitrate-of-silver, a two-per-cent solution of chromic acid, strong acetic acid, etc. A five- to ten-per-cent solution of cocaine is first applied. At the same time use is made of inhalations of chlorate of potash and alkaline waters internally. Gargling in the morning with hot salt water is very serviceable. In the later stages, if the sensitiveness of the mucous membrane has abated, inhalations of a one-per-cent solution of tannin are beneficial. Regard must always be had to any disease of the internal organs that may exist—e. g., of the heart, the stomach, the liver, or the kidneys. Hypertrophied tonsils should be removed with the tonsillotome (see page 425). Simple incision of the tonsils has been recommended recently in place of tonsillotomy in cases of chronic follicular tonsillitis (Hofmann, M. Schmidt, and others).

In the atrophic form of chronic pharyngitis and tonsillitis cauterization is not to be recommended. The crusts should be removed by nasal douches, sprays, and inhalations. To this end solutions of common salt, soda, or antiseptic solutions, especially permanganate of potash (1 : 2,000–3,000) or weak

solutions of carbolic acid, thymol, or boric acid are used. The insufflation of finely powdered boric acid into the nasal pharynx is also serviceable.

In every case of chronic pharyngitis attention should be paid to the condition of the nose, and the chronic rhinitis which usually exists in these cases is to be treated in accordance with the directions given on page 272.

For the treatment of adenoid growths in the naso-pharyngeal space (the pharyngeal tonsil), which are so common in chronic pharyngitis, see page 434 (New Growths of the Pharynx); for the treatment of chronic inflammations of the lingual tonsil at the base of the tongue, which are also very common, see page 377.

As regards the motor neuroses of the velum palati it is of importance that the pneumogastric is the only motor nerve of the same, the facial having no part in the innervation (Réthi). Paraylsis of the velum results from various causes, such as diphtheria, hypertrophied tonsils, lymphomata of the neck, etc. The uvula inclines sometimes toward the sound and sometimes toward the paralyzed side. Deviation of the uvula occurs also without paralysis, as in semilateral degeneration of the azygos uvulæ muscle.

An hypertrophied uvula, which causes reflex coughing and clearing the throat by irritating the base of the tongue or the glottis, especially while the patient is lying down, should be amputated. Its tip is seized with a tenaculum or a mouse-toothed forceps, and it is then cut off with curved scissors. The bleeding, which is insignificant, either stops spontaneously or after gargling with cold water.

Tonsillotomy.—Hypertrophied tonsils, as we have already stated above, must be removed—that is, the projecting part of the tonsils is cut away.

The best tonsillotome is Mathieu's (see Fig. 250), which is conveniently managed with one hand. The thumb is introduced into the ring at the end, the forefinger and middle finger into the two rings on the sides. The use of the instrument is very simple. After the tonsils have been painted for two or three minutes with a five-per-cent solution of cocaine, to produce local anæsthesia, the head of the patient is held by an assistant, and the tongue is depressed with the left forefinger or a tongue depressor. It is often, however, unnecessary to depress the tongue, because the patient gags in consequence of the introduction of the instrument, and the throat is thus sufficiently opened. The ring of the instrument is laid quickly about the hypertrophied tonsil and the latter is impaled by pushing forward the fork which is on the side toward the median line of the mouth. By means of this fork the tonsil is then drawn somewhat out


Fig. 250.—Mathieu's tonsillotome.

of its niche. The impaled part of the tonsil which is thus drawn outward is then cut off by pushing forward the cutting ring. This slight operation is performed very quickly, and even without the use of cocaine there is but little pain. The bleeding is arrested by gargling with cold water. A patient should never be sent away, however, until the surgeon has satisfied himself that the hæmorrhage has stopped. The patient must be on his guard against draughts of air, dust, etc., for a few days, and must take only non-irritating fluid food. Secondary parenchymatous hæmorrhage sometimes occurs; the friends of the patient should be informed of this and the patient should be kept under observation during the day of the operation. The so much dreaded injury to the internal carotid, which lies outside the lateral wall of the pharynx, behind the tonsils and behind the muscular layer consisting of the stylo-glossus and stylo-pharyngeus muscles, is impossible if tonsillotomy is performed in the right way. It is more likely to occur in case of amputation of the tonsils by means of a galvano-cautery loop. Even if the tonsil is drawn out a good distance, no effect is produced upon the protected situation of the artery. Secondary parenchymatous hæmorrhage may become extreme in hæmophilia or leukæmia, and in case the vessels gap in consequence of a fibrous condition of the tonsils (Schede); also in case the tonsillar artery is injured in the vicinity of the posterior capsule of the tonsil, where the artery is so closely connected with the fibrous covering of the tonsil that it can not contract, but remains patent (O. Zuckerkandl). Hyrtl has called attention to the fact that the ascending palatine artery, from which the tonsillar artery usually branches and which is itself a branch of the facial, may become so enlarged as to give rise to the remaining branches, which usually arise from the internal maxillary artery. It is therefore evident that severe and even fatal hæmorrhage may result from tonsillotomy in consequence of so marked a development of the ascending palatine artery.

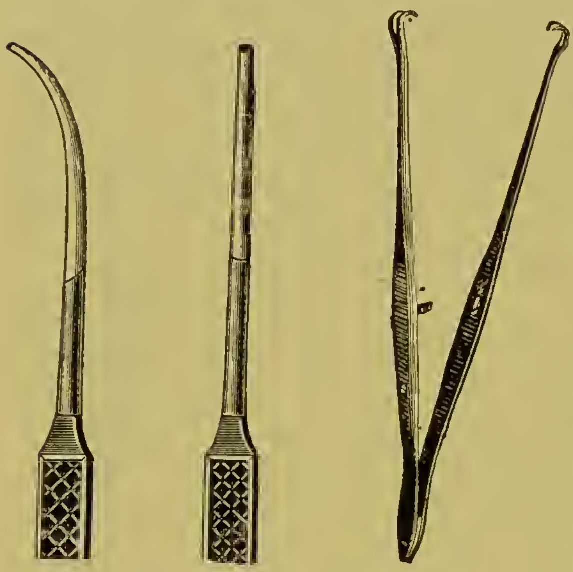


Fig. 251.—Instruments for performing tonsillotomy: curved (*a*) and straight (*b*) probe-pointed knives and mouse-toothed forceps (*c*) for the removal of hypertrophied tonsils.

This secondary parenchymatous hæmorrhage is arrested by pieces of ice in the mouth, by applying an ice bag, by compression with the finger or a stick sponge, or by Paquelin's thermo-cautery. The patient must, above all, sit as upright as possible. For compression of the bleeding tonsil Ricord invented a forceps-shaped instrument which has been modified by Mikulicz. The tonsil and its surroundings are pressed together from within and from without by the pads of this instrument, and after the latter has been applied the arms of the forceps or their rings are bound together. It may be found necessary to tie the external carotid artery.

I sometimes remove hypertrophied tonsils with a curved probe-pointed knife after I have seized the tonsil with vulsellum forceps and drawn it somewhat outward (see Fig. 251). With this curved knife, or with a straight probe-pointed knife, the tonsil is cut along the palatine arch from above downward with sawing strokes. For the right tonsil the knife is held in the left hand, or one may cut from behind.

I consider that the removal of the tonsils by use of the loop of a galvano-cautery is not without danger, in view of the possibility of injury to the internal carotid artery. Mariel recommends removal of the tonsils with the cold snare. It is easy, and comparatively painless.

Pharyngo-mycosis Leptothrica appears, according to Hering and others, principally on the tonsils and base of the tongue, and is characterized by the development of white or yellowish-gray, soft or, less frequently, horny excrescences. The local disturbances are usually slight, inflammatory manifestations being rare. Microscopic examination shows that the substance removed consists of characteristic leptothrix threads with a closely compacted, fine, granular material and pavement epithelium. The best reaction for leptothrix is weak Lugol's solution of iodine, which colours the constituents—i. e., the starch—blue. It has repeatedly been mistaken for tuberculosis.

The treatment of pharyngo-mycosis consists in the use of antiseptic washes, and especially in removal of the tonsils. If antiseptics are without effect, the galvanic current has repeatedly been applied with success (positive pole upon the diseased spot).

In pemphigus of the skin, blebs filled with blood or a sero-purulent material have been seen to form in rare cases on the mucous membrane of the naso-pharynx, the larynx, and the mouth. These ran their course without special subjective disturbances and soon changed into fibrinous coatings.

Bursitis pharyngealis (Tornwaldt's disease) is, in the majority of cases, combined with suppuration within the nose and neighbouring cavities (Ziem). The pharyngeal bursa lies about one centimetre deep in the upper posterior wall of the pharynx or of the naso-pharyngeal space, and presents a depression or recess of the mucous membrane and is frequently, according to Tornwaldt, the seat of acute inflammation, whereby the usual mucous secretion becomes purulent. Bursitis pharyngealis is said to lead frequently to chronic pharyngitis and to be the most frequent localization of the altered secretion

in diseases of the naso-pharynx. Poelchen also confirms this. In the opinion of other authors, especially Gellé (Paris), for example, the pharyngeal bursa, and therefore Tornwaldt's disease, is of extremely rare occurrence.

Tuberculosis of the Throat and Palate occurs only with simultaneous tuberculosis of other organs, especially the larynx and the lungs. Tuberculosis of the skin of the face (lupus) or tuberculosis of the tongue frequently exists at the same time,.

Tuberculosis of the throat and palate begins, as a rule, with a rather uniform thickening of the mucosa and submucosa, in which very small tubercles or tubercular nodules the size of a pea make their appearance. Ulcers of about the same size, or larger confluent ones, with a cheesy base, soon develop upon the pillars of the fauces, on the posterior wall of the pharynx, and on the posterior surface of the velum. With sufficient illumination there are seen between these tubercular ulcers the small miliary nodules which are characteristic for the diagnosis. Perforations of the soft palate rarely result from tubercular ulcers, but deformities due to cicatricial contraction are not infrequent. Aside from the ulcerative form of tuberculosis there occurs here also, just as in the other parts of the mouth, the tuberous form—that is, larger, painless nodules form beneath the mucous membrane which gradually increase in size, finally break down, become caseous, and suppurate (see page 374, Tuberculosis of the Tongue).

Tuberculosis of the hard palate also takes the form of tubercular caries, which, like the syphilitic, leads to perforations of the hard palate, but its progress is much slower than that of the latter.

There are likewise observed upon the tonsils in tuberculosis of the palate and throat irregular ulcers of considerable size with a cheesy base. The neighbouring lymph glands are almost always attacked by the disease.

For a description of the tubercular retropharyngeal abscesses resulting from tubercular inflammation of the cervical vertebræ which form smooth-walled, fluctuating tumours of the posterior wall of the pharynx, the reader is referred to diseases of the neck and the cervical vertebræ.

The diagnosis is made from the presence of tuberculosis in other organs, and especially from the detection of the tubercle bacilli (see Principles of Surgery, § 83) and of the miliary tubercles in the vicinity of the ulcers. Tuberculosis of the palate and throat may be confounded clinically mainly with syphilis. As regards the differential diagnosis it is to be emphasized that syphilis is more likely to cause defects, whereas tuberculosis causes more extensive ulcerations with a tendency to contractions and adhesions. Tubercular ulcers are also more painful and have a more marked inflammatory reaction.

The prognosis of tuberculosis of the palate and throat is very dubious, as tuberculosis of other organs usually exists. Most patients die from tuberculosis of the lungs or the larynx. Undoubted permanent recoveries have been observed, especially from the primary tuberous form of the disease.

The therapy of tuberculosis of the palate and throat consists in an energetic local treatment and in improving the general condition of the patient by means of a suitable mode of life (see Principles of Surgery, § 83, page 420). The local treatment is the same as for tuberculosis of the tongue. The tubercular ulcers are best destroyed by the galvano-cautery. After cauterization, inhalations of weak carbolic acid (one per cent), chlorate of potash, or boric acid, etc., follow. Treatment of the ulcers with iodoform and occasionally with the nitrate-of-silver stick or chloride of zinc (five to ten per cent) is strongly to be recommended.

Syphilis.—Syphilis manifests itself on the palate and in the pharynx, much as on the outer skin, as a pronounced hyperæmia (angina syphilitica erythematosa) with whitish coated erosions, and also by the formation of mucous patches—that is, of flat, pearl-coloured elevations with red margins which appear sometimes in considerable numbers. From the breaking down of these nodules corresponding small ulcers may form, and from their confluence larger ulcerated areas may arise.

The gummata which appear during the later stages of syphilis in the soft parts or the bone are much more unfavourable. In the periosteum of the hard palate and in the submucosa of the velum palati, the tonsils, and the pharynx, nodules the size of a pea to that of a bean develop, which are at first hard and then softer, and may sometimes entirely disappear under proper treatment, but which more frequently break down and thus cause gummatous ulcers. These ulcers often grow rapidly, and may lead to serious defects in the hard and soft palate. The destructive process in the hard palate usually begins within the nasal cavity from syphilitic ozæna. The gummatous ulcers of the soft palate also, which run a very rapid course, causing in a few weeks marked destruction, arise most commonly in the upper naso-pharyngeal space in the region of the posterior nares, and are often first recognised when the soft palate is already perforated. Perforation of the hard and soft palate gives rise to that characteristic nasal speech which we already mentioned in § 63 when speaking of defects of the palate.

From the healing of syphilitic ulcers of the posterior wall of the pharynx and the soft palate there may ensue more or less adhesion of these two parts with each other. In case of complete adhesion of these parts there arise, in addition to disturbances of speech, those subjective inconveniences which we became familiar with in connection with op-

erations for cleft palate (Passavant and Schönborn-Trendelenburg operations). The patient is tormented, above all, by the impossibility of properly cleansing the naso-pharyngeal space.

From syphilitic ulceration of the posterior and lateral walls of the pharynx, with simultaneous gummatous processes in the posterior region of the tongue, circular strictures of the pharynx, due to cicatricial contraction, may result to such an extent that the entrance to the larynx and œsophagus is narrowed or partly closed by a white cicatricial membrane stretching from the base of the tongue to the posterior pharyngeal wall. This may be demonstrated with the laryngoscopic mirror. Trendelenburg, Schech, Lublinski, and Pauly have described characteristic cases of this circular stricture of the pharynx.

To prevent strictures of this kind one should assure himself in every case of syphilis of the pharynx of the condition of the parts more deeply situated by means of the laryngoscope.

Syphilitic processes within the naso-pharyngeal space are also of great practical importance. Serious changes may exist here without causing marked local symptoms (Gerber). A careful examination of the naso-pharynx should therefore always be made.

The syphilitic lesions in syphilis of the pharyngo-oral cavity too often heal only apparently while syphilitic cellular infiltrations remain behind, which, owing to the mechanical, thermal, and chemical irritations which are here so frequent, are stirred to new activity. In this way are to be explained the frequent relapses or the late forms of syphilis of the naso-pharynx.

The therapy of syphilis of the pharynx and palate consists in a general antisyphilitic course of treatment (see Principles of Surgery, § 84) and an energetic local treatment (scraping with the sharp spoon, cauterization of the spreading ulcers, especially, with the galvano-cautery, application of iodoform or other antiseptic powders, inhalations, etc.).

Defects in the hard and soft palate are, if necessary, closed by means of uranoplasty and staphylorrhaphy, or by the use of obturators.

In case of complete growing together of the soft palate with the posterior wall of the pharynx, communication between the nose and the pharynx is restored by breaking up the adhesions and maintaining the opening by means of a conical dilatation bougie. If the patient is anæsthetized, the operation is performed with the head held forward, or it may be done under local anæsthesia by painting the parts with a five- to ten-per-cent solution of cocaine. The formation of a sufficiently large hole in the soft palate is less to be recommended. In several cases the entire soft palate has been extirpated (Ried).

The circular strictures situated low down in the pharynx are divided with a probe-pointed knife (e. g., after Tobold), and then dilated with Schröter's tubes (see larynx) after first performing tracheotomy. Operative interference with the knife in cicatricial strictures of the pharynx due to syphilis is not without danger, owing to the close proximity to numerous arteries and the small amount of space. Thiersch was forced in one case to tie the common carotid artery.

§ 69. **New Growths of the Palate, the Pharynx, and the Tonsils.**—New growths of the palate are of rare occurrence. Dermoid cysts are sometimes observed on the hard palate, and especially fibroma and sarcoma. These two varieties of tumour usually start in the periosteum of the palate plate. Tumours of the latter must not be confounded with herniæ of the brain membranes or of the brain (cephaloceles), which generally make their way through the hard palate and appear in the oral cavity (see Fig. 74, page 158).

Carcinoma of the hard palate almost always arises from the extension of a carcinoma in the immediate neighbourhood. Primary carcinoma of the hard palate is rare.

Tumours of the soft palate are still more uncommon than those of the hard palate. We have most frequently to do with carcinomata, which, as a rule, however, do not form here primarily, but have spread to the soft palate and the tonsils from the dorsum of the tongue, from the mucous membrane of the cheek, from the gum near the wisdom teeth, or from the pharynx.

Among primary tumours arising in the soft palate there should be mentioned especially mucous polyps, adenomata on the pillars of the fauces, retention cysts of the mucous glands, and papillomata, which may be either sessile or pedunculated. Adenomata of the soft palate may attain the size of a walnut, or even that of a hen's egg. Fibroma, myoma, lipoma, myxoma, and sarcoma of the soft palate have very seldom been reported. The occurrence of hairy polyps of the pharyngo-oral cavity is of special interest. These have a covering of epidermis, rete Malpighi, and corium (J. Arnold, Schütz). R. Otto removed a hairy polyp of the pharynx as large as a walnut, in the case of an infant seventeen hours after birth, which had occasioned extreme difficulty in breathing. The tissue under the cutaneous covering sometimes consists only of fat. These hairy pharyngeal polyps are to be traced back, according to J. Arnold, to a displacement of embryonic tissue, and are to be designated as teratomata.

Poncet observed an adeno-chondroma of the soft palate in a man fifty years of age, who, after his admission to the hospital, died of asphyxia, although tracheotomy was performed at once. Aside from

adeno-chondroma, similar mixed tumours occasionally develop in the hard and soft palate and on the inner side of the lips and cheeks which are partly of epithelial and partly of connective-tissue origin. They are not pure adenomata or epitheliomata, but are adeno-chondromata, adeno-fibromata, adeno-myxomata or fibro-epitheliomata, myxo-epitheliomata, and chondro-epitheliomata (De Larabrie). Cyst formation not infrequently occurs, or the tumours become malignant and change into carcinomata.

Tumours of the hard and soft palate are best operated upon with the head hanging over the table, or tracheotomy may be performed beforehand and the trachea or entrance to the larynx packed (see operations on the larynx and trachea, § 106). In this way the aspiration of blood into the air passages and lungs, which is so dangerous, is avoided. Smaller and particularly pedunculated tumours may be removed under local anæsthesia by painting the parts with a five- to ten-per-cent solution of cocaine.

On the tonsils, carcinomata and very malignant round-celled sarcomata (the so-called medullary cancers) are found. Carcinomata and sarcomata of the tonsils are often marked by extensive ulceration, with much sloughing and rapid loss of strength.

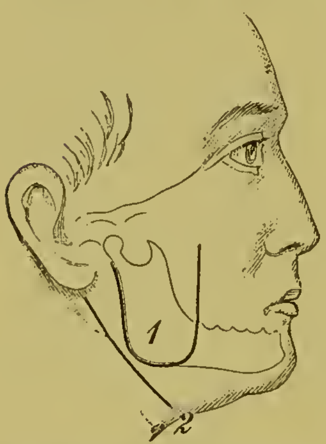


Fig. 252.—Extirpation of the tonsils: *1*, Langenbeck's incision; *2*, Mikulicz's incision.

The removal of carcinomata and sarcomata of the tonsils may be accomplished in a way similar to that described in § 61 for the removal of tumours of the base of the tongue and for the complete extirpation of the tongue. Lateral division of the jaw, after Langenbeck, is especially to be recommended here. By Langenbeck's method a tongue-shaped incision is made through the skin with its base upward (Fig. 252, 1). After tying the facial artery, the lower jaw is sawn through in front of the edge of the masseter. The ramus of the lower jaw is displaced upward, care being taken of the muscles of mastication. The involved tonsil, the soft palate, and the pharyngeal wall can now be excised through sound tissue. It is advisable, by way of precaution, as Genzmer also recommends, to pass a catgut ligature loosely about the common carotid, so as to be able to tie it at once if necessary. After completing the operation, the ramus is again united with the other portion of the jaw by suture.

Verneuil's method is also to be recommended for the extirpation of intra-buccal tumours; it is similar to Kocher's method for removal of the tongue

(see page 392). An incision is made through the skin from the corner of the mouth downward to the border of the lower jaw and along the latter as far as the angle. The different layers are divided down to the mucous membrane, the facial artery being cut between two ligatures. The submaxillary and any lymph glands are removed and the external carotid tied, having been exposed by following the facial artery to its origin. The mucous membrane is now divided along the lower jaw and the buccal cavity opened.

I have twice extirpated sarcoma of the tonsils by Mikulicz's method with good results, and I can recommend it most warmly. It is performed as follows:

Low tracheotomy is performed some days beforehand, so as to be able, during extirpation of the tumour of the tonsils, to pack the opening of the larynx firmly with a sponge or iodoform gauze, or to lay in a tampon canula, after Trendelenburg, Michael, or Hahn (see § 106). The removal of the tumour of the tonsils is then begun by a skin incision seven or eight centimetres below the mastoid process along the anterior border of the sterno-mastoid muscle as far as the greater cornu of the hyoid bone (Fig. 252, 2). All the soft parts down to the inferior maxilla are divided in layers, the bone is bared of periosteum a good distance upward and divided by the chain saw near the point of insertion of the masseter and internal pterygoid muscles, and then the ramus of the lower jaw is enucleated without injuring the mucous membrane. Any diseased lymph glands and the tumour are freed from the outside without entering the mouth until the tumour is attached only to the mucous membrane of the mouth and pharynx. This is now divided after careful arrest of hæmorrhage, and the oral and pharyngeal cavities are thus opened for the first time. The operation is now finished by a few cuts with the scissors, so that but little blood enters the pharynx. The entire cavity of the mouth is finally packed with iodoform gauze, and the patient fed for a time by means of the stomach tube.

The advantages of this method of Mikulicz are, that the operation can be conducted in deep narcosis almost to its very end without opening the cavities of the mouth and pharynx, the arrest of hæmorrhage is easy, and, finally, the entire wound can be packed with iodoform gauze, whereby aseptic healing is most surely secured. Mikulicz at first declared that preliminary tracheotomy and packing the trachea could be dispensed with, but in his later cases he has, if I am not mistaken, like myself, performed tracheotomy and plugged the trachea. The disturbances arising from the removal of the ramus of the lower jaw are slight, if only the points of insertion of the masseter and internal pterygoid are spared.

Adenoids.—Of tumours in the pharynx, adenoid growths in the naso-pharyngeal space interest us especially. These arise most commonly in the pharyngeal tonsil on the roof of the pharynx (see page 267, Fig. 165). They occur most frequently in children, as the result of chronic catarrh of the pharynx with the formation of granulations. Adenoid growths or hyperplasia of the pharyngeal tonsil are analogous to hypertrophy of the tonsils proper. In Fig. 253 a rhinoscopic picture, after Meyer, is given of these adenoid growths in the naso-pharynx. One may very easily detect the presence of these vegetations by carrying the forefinger bent like a hook upward behind the velum palati. The greatest trouble arising from these growths is their interference with nasal respiration, so that persons thus affected are always obliged to breathe with open mouth. Through closure of the Eustachian tubes hearing is affected, in consequence of interference with the ventilation of the tympanic cavity. In case of long continuance of the growths at an early age, the upper jaw is strikingly retarded in its development (Moldenhauer).

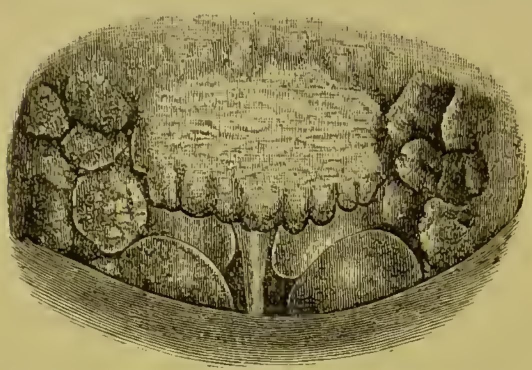


FIG. 253.—Rhinoscopic picture of adenoids in the naso-pharynx (after Meyer). The orifices of the Eustachian tubes are closed by vegetations and a fringed piece of tissue with its insertion above is suspended behind the posterior nares.

Among the more unusual symptoms resulting from hypertrophy of the pharyngeal tonsil are to be mentioned frequent retching and vomiting, spasmodic attacks of coughing similar to whooping-cough, and reflex paralysis of the vocal cords (O. Seifert).

Treatment of Adenoids.—Mild degrees of hyperplasia are very common with children, and often spontaneously disappear from the use of cod-liver oil, iodine, iron, brine baths, sea baths, etc.

Adenoid growths of the naso-pharyngeal space may be removed in various ways—most simply, for example, by means of the finger nail inserted behind the velum palati, or by means of a little scraper attached to the finger. Forceps-like instruments may also be used, Schech's forceps, for instance, the blades of which are like a round, sharp spoon (see Fig. 254), or Justi's sharp spoon with a pliable or rigid handle, after Trautmann (see Fig. 255 *a*). Moldenhauer recommends Meyer's curette (see Fig. 255 *b*) for scraping out adenoid growths. Lange's curette (see Fig. 255 *c*), Michael's forceps, Gottstein's curette, and the sharp-spoon forceps of Halbers, which may be taken apart, are all serviceable.

All these instruments having the form of a forceps or a spoon are introduced into the naso-pharyngeal space from within the mouth. There are, moreover, snare-shaped instruments in use which are employed either in a cold or heated state (galvano-cautery snares). I am not in favour of using the galvano-cautery for the removal of these adenoid growths. The operation is best performed under local anæsthesia with cocaine. It is often a good plan to introduce the sharp spoon or the curette through the nose, and then carry the left forefinger from within the mouth upward behind the soft palate to control the instrument while in operation.

The hæmorrhage generally stops of itself after gargling with cold water. The after-treatment consists in keeping the patient in bed for

Fig. 254.—Schech's forceps for crushing and tearing away adenoids.

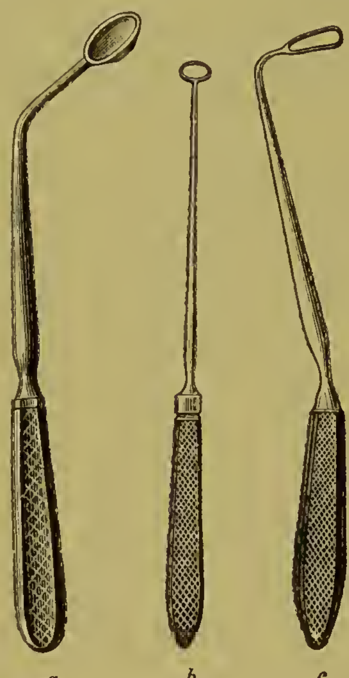


Fig. 255.—*a*, Trautmann's sharp spoon; *b*, Meyer's curette; and *c*, Lange's for scraping out adenoids.

a day or two, as otherwise secondary inflammation of the middle ear may occur.

Naso-pharyngeal Polyps.—Of other tumours of the pharyngeal cavity, those are especially to be mentioned which arise from the vault of the pharynx—i. e., the base of the skull. Here belong, above all, the so-called fibrous polyps of the naso-pharyngeal cavity, or, more correctly, fibromata of the base of the skull (see Fig. 256), which are observed especially in young persons from the age of twelve to twenty, particularly boys. Their point of origin is usually the periosteum, and their favourite locations are the spheno-occipital synchondrosis, the body of

the sphenoid bone, the sphenoidal sinuses, and the aponeurosis of the foramen lacerum anterius. They begin, for the most part, as sessile

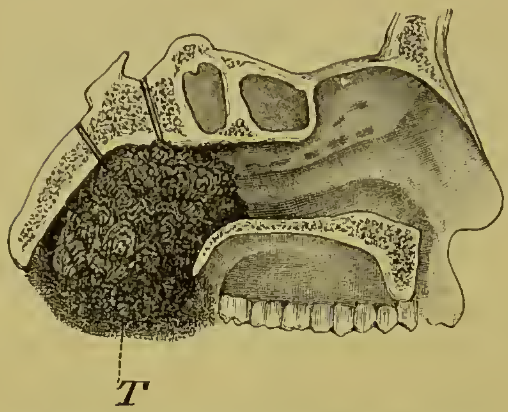


FIG. 256.—Fibrous polyp of the upper pharyngeal wall (base of the skull): *T*, tumor.

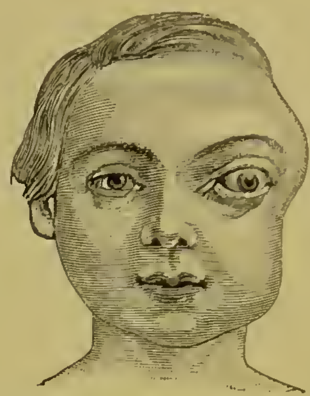


FIG. 257.—Naso-pharyngeal polyp of the left side with a retromaxillary and orbital prolongation.

pharyngeal polyps, and grow forward into the nasal cavity and downward into the pharynx as fibrous naso-pharyngeal polyps. These tumours sometimes arise farther forward also on the inner side of the pterygoid process, and it is these especially that grow, as a rule, more in the direction of the nasal cavity than toward the pharynx.

Another class of fibromata originate farther forward and more to one side in the spheno-maxillary fossa behind the superior maxilla, and, as Langenbeck in particular first described them, make their way, after erosion of the perpendicular plate of the palate bone, into the nasal cavity, and, after destruction of the posterior wall of the upper jaw, into the antrum of Highmore. They may then proceed through the infraorbital fissure into the orbit, and make their appearance in the temporal fossa and under the zygoma.

Finally, analogous tumours have been seen to arise from the anterior surface of the cervical veterbræ in the form of retropharyngeal tumours.

All these tumours are, as a rule, at first hard, sessile fibromata, which grow at the beginning in the direction in which they meet the least resistance. In their further course the bones which stand in their way become eroded, especially the vomer, the turbinated bones, the palate bones, the walls of the superior maxilla, etc. The cranial cavity is also penetrated in rare cases, especially by fibromata, which afterward become sarcomatous (see Fig. 258, after C. O. Weber).

A large number of these fibromata are very vascular, and patients may become so weak from loss of blood as to render the removal of the tumours for this reason also a pressing necessity. Many fibromata

increase in size for a time and then diminish, so that the subjective disturbances are correspondingly variable.

Fibrous naso-pharyngeal polyps usually grow slowly at first, so that they attain in the course of some years, for instance, the size of a hen's egg. Sarcomata grow more rapidly, and are distinguished by their tendency to penetrate into the cranial cavity. Fibromata which are at first hard become constantly softer and richer in cells as time goes on —that is, they take on the character of sarcomata. The tumours at first give little trouble or none at all. As they progress, difficulties in swallowing and breathing arise, and, through compression of the epiglottis, suffocation may ensue. Perforation of the cranial cavity is usually very gradual and without special symptoms. In exceptional cases a radical cure has been observed in consequence of a spontaneous sloughing off of the tumour. It is an important fact that in young persons at the end of puberty the naso-pharyngeal polyps sometimes disappear by gradual atrophy.

Death often results finally from perforation into the cranial cavity, or from compression of certain vital structures (nerves, pharynx, larynx, blood-vessels), or from hæmorrhage.

The diagnosis is usually easy as soon as the tumour has reached a certain size. It can be distinguished from adenoid growths by its hardness and its roundish, smooth surface. The presence of the tumour in the naso-pharyngeal space is easily demonstrable by palpation. In the later stages it may become visible at one of the nostrils and behind the soft palate. The entire side of the face that is affected is often swollen, the bulb may be displaced, and the growth may frequently be felt beneath the zygoma (Fig. 257).

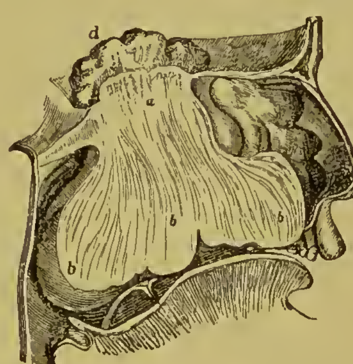


FIG. 258.—Fibrous polyp of the naso-pharynx (*a b*) with sarcomatous degeneration and perforation of the skull (*d*).

The treatment of naso-pharyngeal polyps, or, more accurately, of all the above-mentioned tumours of the base of the skull, consists, in consideration of their pronounced malignity, in their earliest possible complete extirpation. The removal of naso-pharyngeal polyps is sometimes possible without preliminary operation—by means of the snare of the galvano-cautery, for instance, or crushing forceps, or the chisel. Usually, however, to make a thorough extirpation, sufficient access must first be gained to the starting point of the tumour at the base of the skull. This is best accomplished by osteoplastic resection of the superior maxilla, which has already been described (page 355).

Kocher performed osteoplastic resection of both superior maxillæ for recurrent sarcoma of the naso-pharynx.

In place of temporary or osteoplastic resection of the superior maxilla for naso-pharyngeal polyps with retromaxillary and orbital prolongations, which is not without danger, Bruns recommends removal of the naso-pharyngeal portion of the tumour through the natural passages, and at a second operation extirpation of the orbital portion, it may be, by temporary resection of the malar bone. If the orbit is free, an oblique incision with a slight curve backward is made behind the outer canthus from the upper border of the temporal fossa to above the level of the corner of the mouth. A horizontal incision meeting this first one is then made along the upper border of the zygoma. In the line of the first incision the body of the malar bone is sawn through with a metacarpal saw, and in the second the posterior end of the zygoma is divided with the chisel. If a prolongation of the tumour has entered the orbit, the entire malar bone, together with its orbital portion, is turned out. For this purpose a vertical incision is made, beginning one centimetre behind the outer canthus with a slight anterior convexity, and a horizontal incision from the outer canthus along the zygoma to a point just in front of the ear. The bone is then divided at three places: (1) Horizontally at the junction of the malar bone with the frontal bone; (2) vertically at the junction with the superior maxilla through the infra-orbital fissure; and, finally, (3) at the posterior end of the zygoma.

In case of small naso-pharyngeal polyps on the body of the sphenoid bone, and especially in case of tumours of the posterior pharyngeal wall, complete division of the soft palate in the median line, after Manne, is often sufficient; this is done with the head hanging over the table. The tumour is then seized with a Museux's forceps and cut away with strong scissors curved on the flat. Hæmorrhage is stopped by compression, and the pedicle of the fibroma is thoroughly cauterized. The wound in the palate is kept open for several days, and it finally closes spontaneously or the edges are freshened again, if necessary, and united by suture as in staphylorrhaphy (see page 404).

Böckel has recommended a transverse detachment of the soft palate at its base instead of Manne's longitudinal incision. Nélaton made a longitudinal incision in the middle line of the hard palate in addition to Böckel's transverse incision, then separated the soft parts from the hard palate along this T-shaped incision, and secured sufficient access to the tumour through the horizontal plates of the palate bones and the palate processes of the superior maxillary bones. Gussenbauer's method is more practical. He divides the muco-periosteal covering of the hard palate in the median line, and detaches both muco-periosteal

halves from the bone as far as the alveolar processes, much as in uranoplasty, and finally chisels away as much as is necessary from the hard palate. The defects caused by these partial or complete removals of the hard palate are filled in again later by a new growth of bone after the muco-periosteal covering has united.

Access could be gained to the base of the tumour through the nose in accordance with the methods described on pages 280–282, but these operations do not answer for extensive tumours. König has recommended the following new method of operating from the nose upon naso-pharyngeal polyps: Division of the nose along the middle line of its dorsum to the right or left side, according to the situation of the growth in the nasal cavity, and the flaps are held apart by sharp retractors. The nasal cavity is then sufficiently dilated by introducing the finger. Should one nostril, owing to a deviation of the septum, for instance, be too narrow, the other nostril is used. The tumours are now forcibly torn away by means of large and strong but not very sharp spoons, which completely fill the breadth of the nasal fossa, and which are controlled by the forefinger introduced through the mouth behind the soft palate. For the great majority of cases this method suffices, according to König, but it is of course not suited for extensive naso-pharyngeal tumours which have grown into the antrum of Highmore, into the spheno-maxillary fossa, etc. Furneaux Jordan has gained access to the right or left bony aperture of the nose (apertura pyriformis) by cutting a triangular flap from the upper lip and the ala nasi on that side. He does this by opening the nasal cavity on one side along the septum, then dividing the upper lip by continuing this incision from above downward, and finally raising the flap and retracting it to one side. The methods of Jordan and König may be combined in a practical manner—e. g., incision through the skin according to Jordan, and the remainder of the operation after König.

Besides the use of scissors and knife, the tumour may also be removed by the galvano-caustic loop. Ligation and the écraseur are scarcely used at present.

Ciniselli, Nélaton, and Bruns have also recommended electrolytic treatment of naso-pharyngeal polyps—that is, the introduction of needles and application of a strong electric current which causes the tumour to become necrotic. Voltolini, C. Michel, and Michelson have also seen favourable results from the use of this method.

Inasmuch as after puberty these tumours sometimes cease to grow, and even diminish by atrophy and disappear, Gosselin recommended the excision of small pieces from time to time from the tumour in all those cases in which extensive preliminary operations for complete

removal are necessary but too dangerous. In this way the pain at least is alleviated, and time is gained until after puberty, when it is possible that the tumour may cease to grow.

All partial extirpations are without danger and easy to perform, but they are harmful, in my opinion, inasmuch as the tumours usually then grow more rapidly, and the favourable time for complete extirpation is lost. The latter is only possible when sufficient access to the base of the tumour is secured, and this is best accomplished by osteoplastic resection of the upper jaw after Langenbeck, which is not dangerous (see page 356).

Primary carcinomata of the pharynx are rare. They are best removed by subhyoid pharyngotomy, with resection or excision of the pharynx (see § 70).

§ 70. **Subhyoid Pharyngotomy and Excision of the Pharynx.**—Pharyngotomy—that is, opening the pharynx from the outside—is most commonly performed for the removal of foreign bodies or tumours in the pharynx and its immediate vicinity which are not accessible from the mouth. The pharynx may be opened from below at the lower border of the hyoid bone (subhyoid pharyngotomy) or from the side. Subhyoid pharyngotomy was first performed by Malgaigne, for the purpose of removing foreign bodies from the larynx and tumours of the epiglottis and vocal cords. Malgaigne called the operation subhyoid laryngotomy, but Langenbeck proposed the name of subhyoid pharyngotomy, which is more correct, because, as a matter of fact, the lower part of the pharynx and not the larynx is opened in performing the operation (see Fig. 259 *a*, schematic after Roser). This operation is therefore especially well adapted for the extirpation of tumours of the lateral and posterior pharyngeal walls, of the epiglottis and of the aryteno-epiglottidean folds, as well as for the removal of foreign bodies in the pharynx and larynx.

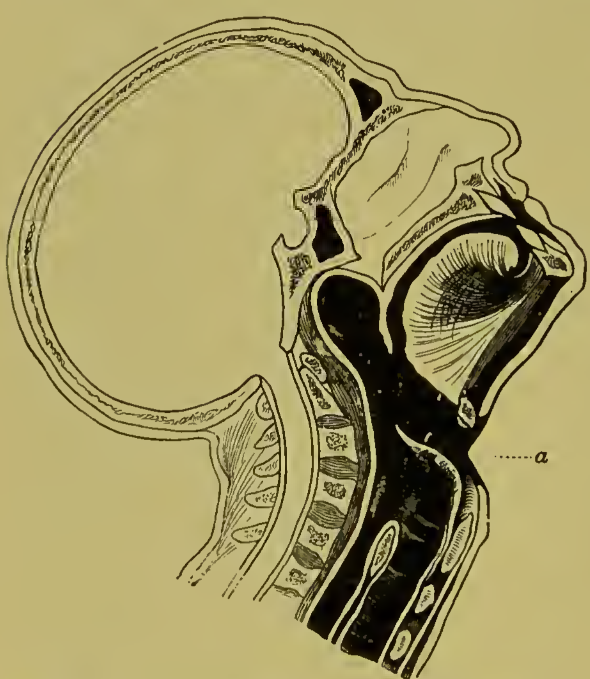


Fig. 259.—Subhyoid pharyngotomy (diagramatic).

Hueter says with truth that subhyoid pharyngotomy was really first invented by suicides who try to cut their throats. Suicides place the knife by special preference on the pomum Adami; the blade then glides upward between the thyroid cartilage and hyoid bone, and opens the pharyngeal cavity in front of the epiglottis at the point designated *a* in Fig. 259.

Subhyoid pharyngotomy is performed in the following manner: A transverse incision through the skin is first made along the lower border of the hyoid bone as far as the tips of the greater cornua. After going through the skin, the fascia and the inner border of the platysma, the sterno-hyoid, and thyro-hyoid muscles are divided, and the superior laryngeal artery is tied if necessary. The thyro-hyoid membrane is now exposed, and is opened by introducing a pointed knife at the lower end of the hyoid bone and carrying it obliquely upward. In order that the mucous membrane may be divided close in front of the epiglottis, corresponding to the fossa glosso-epiglottica, the left forefinger may be carried there from within the mouth. Through the opening that has been made the membrane is then detached from the posterior surface of the hyoid bone with a probe-pointed knife. Access to the pharynx and to the entrance of the larynx can be much facilitated, if necessary, by dividing the greater cornua of hyoid bone one or two centimetres from their free ends with scissors. This can easily be done without injury to the lingual artery and the superior laryngeal nerve. By retracting the edges of the wound one sees the epiglottis, and can conveniently draw it out through the wound so as to look into the larynx. The aryteno-epiglottidean folds are also drawn outward at the same time, and if one separates the larynx somewhat from the tongue, the lateral and posterior walls of the pharynx can be thoroughly inspected. Tumours of the posterior and lateral walls of the pharynx, of the epiglottis, and of the aryteno-epiglottidean folds can be conveniently extirpated. The ascending pharyngeal artery, if cut, should be quickly tied, in order that blood may not flow into the air passages. Tumours of the first part of the œsophagus may also be removed by subhyoid pharyngotomy after preliminary tracheotomy and plugging of the trachea has been performed. For excision of the first part of the œsophagus a second longitudinal excision is made in a straight or oblique downward direction upon the side on which most of the tumour lies (Iversen, Küster).

In consideration of the narcosis and hæmorrhage, the extirpation of tumours should always be preceded by tracheotomy and the entrance to the larynx plugged with a sponge or iodoform gauze.

After excision of a part of the pharynx, the defect will be allowed

to granulate, and the epiglottis secured in its normal situation by suture, if necessary. By packing the trachea and the pharynx, and by introducing a stomach tube for feeding the patient, aseptic healing is most likely to be secured, and suppurative mediastinitis and aspiration-pneumonia prevented.

Lateral Pharyngotomy.—Langenbeck has also extirpated carcinomata of the pharynx from the side. The incision through the skin for this lateral extirpation begins on the lower border of the jaw, midway between the chin and the angle of the jaw, and runs in an oblique direction over the greater cornu of the hyoid bone to the level of the cricoid cartilage or still lower. After dividing the platysma and the omo-hyoid, one works inward carefully at the level of the hyoid bone. The lingual and superior thyroid arteries and facial vein are divided between two ligatures and the two branches of the superior laryngeal nerve are cut. After detaching the two tendons of the digastric and stylo-hyoid muscles from the hyoid bone the pharyngeal cavity is opened. Langenbeck has performed excision of a carcinomatous pharynx in this way in three cases. In two cases it was also necessary to remove single parts of the larynx at the same time. All three patients died in consequence of the operation, one living fourteen days. Division of the superior laryngeal nerve seems to favour the aspiration of pus and particles of food into the larynx. Billroth removed both the pharynx and larynx for carcinoma. The patient died six weeks later of posterior mediastinitis. The case operated upon by Gussenbauer also ended fatally. It seems to me very doubtful whether, in cases of such extensive carcinomata, permanent recovery is to be obtained by removal of the larynx and pharynx, inasmuch as the lymphatic glands in the deeper regions of the neck and in the mediastinum are always already diseased.

If it is desired to remove both larynx and pharynx, the larynx should be extirpated first (see § 106), and then the pharynx in the manner just described. Low tracheotomy is of course to be performed beforehand. The after-treatment consists here also, above all, in packing the wound with iodoform gauze, and in feeding the patient through the stomach tube. After extirpation of the pharynx one may immediately replace the posterior pharyngeal wall, according to Witzel, Hacker, Iversen, and Poulsen, by turning in two skin-flaps, and about three weeks after the first operation one may form the anterior pharyngeal wall in a similar manner by means of two flaps of skin with the epidermic surface inward.

CHAPTER VIII.

INJURIES AND DISEASES OF THE EAR.

Examination of the ear.—Injuries and diseases of the auricle: Deformities.—Otoplasty.—Injuries and inflammations.—Tumours.—Injuries and diseases of the auditory canal: Malformations.—Injuries and inflammations.—Collections of cerumen in the auditory canal.—New growths.—Foreign bodies in the ear (auditory canal and middle ear).—Injuries and diseases of the membrana tympani: Malformations.—Injuries.—Tuberculosis.—New growths.

Injuries and inflammations of the tympanum: Malformations.—Injuries.—Inflammations.—Neuroses.—New growths.—Paracentesis of the membrana tympani and other operations on the middle ear.—Injuries and diseases of the Eustachian tube.—Injuries and diseases of the mastoid process.—Trephining the mastoid process.—Injuries and diseases of the internal ear (labyrinth).—The causes of death from diseases of the ear.

The study of the diseases of the ear is of the greatest importance for every physician. It is especially true of ear troubles, which are so frequent, that by correct diagnosis and treatment, particularly at the beginning of the disease, great harm may be prevented and many a brilliant success achieved. Lemcke, for example, has shown that two thirds of all the cases of deaf-mutism that have been occasioned by disease of the organ of hearing could have been prevented by proper treatment.

We can here give only a very brief exposition of the most important injuries and diseases of the ear, in so far as they are of surgical interest. The exhaustive treatment of the subject by Schwartze in Deutsche Chirurgie, Lieferung 32, is most warmly recommended to any who wish to inform themselves more thoroughly on this subject.

§ 71. **Examination of the Organ of Hearing.**—Examination of the ear includes otoscopy, catheterization of the Eustachian tube, Politzer's method of inflation, auscultation of the organ of hearing, and testing the hearing power. Finally, rhinoscopy is indispensable for the diagnosis of diseases of the ear, especially posterior rhinoscopy.

Otoscopy.—By otoscopy is understood mainly the inspection of the auditory canal and the membrana tympani by means of the ear speculum. Ear specula are made of hard India rubber or, better, of silver, and usually have

the form shown in Fig. 260 *a* and *b*. They are to be had, as a rule, in three different sizes. In order to be able to observe the membrana tympani under the influence of rarefaction and condensation of air in the auditory canal, Siegle constructed a pneumatic ear speculum, which was improved by Eysell, and which, in brief, consists of a speculum with an India-rubber tube for rarefying and condensing air in the auditory canal. By means of the pneumatic ear speculum various changes in the membrana tympani—e. g., synechia, relaxation, atrophy—are more easily recognised.

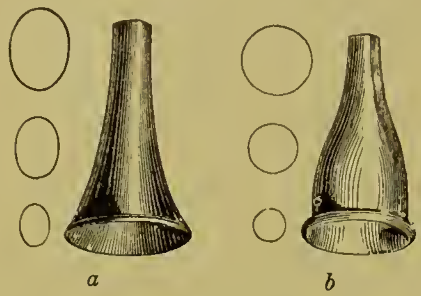


Fig. 260.—Aural specula.

Illumination of the auditory canal and the membrana tympani is accomplished by means of a concave glass mirror having a hole in the centre with silver mounting and a wooden handle (see Fig. 261). If one does not wish to hold the reflector in the hand, but to leave the latter free, a mirror with a frontal bandage is used as in laryngoscopy (see § 101). Ordinary daylight or an artificial light (gas, petroleum lamp, etc.) serves for illumination of the auditory canal and the tympanic membrane. Direct sunlight is to be avoided, as it is too blinding. Drummond's calcium light and the electric light may also be dispensed with, as well as complicated illumination apparatus—e. g., the so-called otoscope, in which ear speculum and reflector are combined in one instrument.

The Technique of Otoscopy.—To overcome the curvature of the auditory canal, the auricle is first drawn backward and upward, less frequently directly backward or backward and downward, depending on the curve in each case. While the auricle is thus held with one hand the ear speculum is pushed with a slight rotating movement and painlessly into the auditory canal with the other hand, until it rests firmly of itself. The auricle and speculum are then held with one hand, the auricle with the middle and ring fingers and the speculum with thumb and forefinger. The other hand holds the reflector. If one wishes to keep one hand—the right, for instance—free for operating, the reflector with frontal bandage may be used, as has been said, or reflector, speculum, and auricle may be held with the left hand, the reflector being grasped with thumb and forefinger, the ear speculum held in place with the middle finger and the auricle drawn backward and upward with the remaining fingers. The auricle may also be drawn backward and upward by an assistant or by the patient himself.

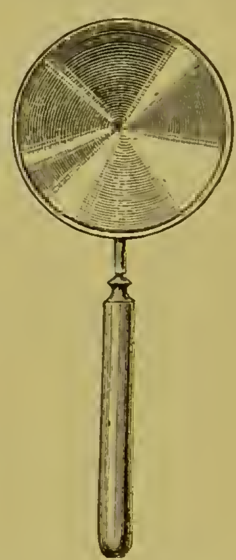


Fig. 261.—Aural mirror.

In order to be able to demonstrate the membrana tympani to a second observer, Hinton invented his demonstration auriscope, with which two persons can see at the same time. It is simpler to use a plane mirror with sunlight, after Lucae. In the plane mirror the second observer, when in a suitable po-

sition turned from the light, sees the inverted image of the membrane. A small adjustable plane mirror may also be placed in the ocular end of the ear speculum and the illumination of the membrane then be accomplished with an ordinary concave mirror (Grünfeld).

The auditory canal has frequently to be irrigated carefully and without strong pressure with lukewarm water or, better, with a warm three-quarters-of-one-per-cent solution of common salt, and then carefully dried with small pieces of sterilized gauze which are wound about a pair of angular forceps (Fig. 262). Vertigo, vomiting, and even fainting are easily occasioned by rough irrigation of the auditory canal.

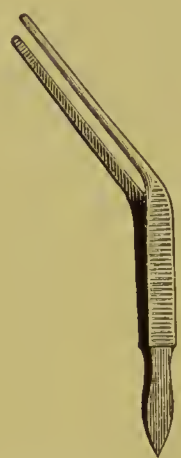


Fig. 262.—Angular forceps for the external auditory meatus.

The normal appearance of the membrana tympani, as it presents itself on inspection, is as follows: Under illumination with reflected daylight it has a pearl-gray colour, while by artificial light it has a more reddish appearance. The border of the membrane, where it is attached to the sulcus tympani, has the appearance of a more or less broad line. In the upper half of the membrane one sees shining through, the manubrium of the malleus running from above and in front downward and backward, and on its upper end the processus brevis is visible as a small white protuberance. In the anterior lower quadrant of the membrane the so-called "cone of rays" is perceptible, the apex of which is directed toward the centre of the membrane. This "cone of rays" is conditioned upon the curvature and upon the inclination of the membrane to the axis of the auditory canal (Wilde, Politzer).

The membrani tympani is not a flat, perfectly level membrane, but, in consequence of the tension of the tensor tympani muscle, is externally concave and funnel-shaped, the greatest concavity being at about its centre ("umbo"). The anterior lower portion is externally more convex. The membrane does not stand perpendicularly but obliquely with reference to the auditory canal, forming with the lower wall of the latter an acute angle and with the upper and posterior walls an obtuse angle of about 140° (Tröltsch).

The normal membrane is but slightly transparent. Occasionally, however, it is so transparent that a skilled observer sees, under good illumination, the promontorium, the long process of the incus, the dark spot representing the fenestra rotunda, and even the chorda tympani.

The degree of convexity, the inclination, colour, and transparency of the membrane, are, moreover, very different in different individuals.

It requires long practice before one can make a satisfactory examination or rightly interpret what one has seen.

Of other methods of examining the ear, catheterization of the Eustachian tube is especially to be mentioned. Special credit is due to Cleland and Deleau for the introduction of catheterization into practice.

Catheterization of the Eustachian Tube.—By catheterization of the Eustachian tube is understood the introduction of a bent tube of silver or hard

India rubber—the Eustachian catheter, so called (see Fig. 263)—through the lower meatus of the nose into the pharyngeal opening of the tube (see Fig. 264).

The Eustachian catheter is grasped like a writing pen so that the curved, beaklike end is directed downward. The tip of the nose is slightly elevated with the left hand, and the catheter is then pushed slowly and carefully along the floor of the nasal cavity from the nostril as far as the posterior pharyngeal wall. It is then drawn somewhat back from this wall until the posterior surface of the soft palate is felt with the beak of the catheter. The beak, which now lies behind the soft palate, is then turned outward and upward for from a quarter to three eighths of a circumference, so that the ring upon the handle of the catheter (see Fig. 263) is directed toward the outer canthus of the eye. Swallowing movements assist the entrance of the catheter into the pharyngeal opening of the Eustachian tube (see Fig. 264).

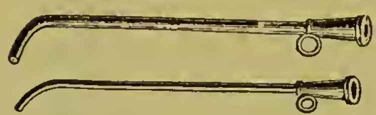


Fig. 263.—Eustachian catheters of two different sizes.

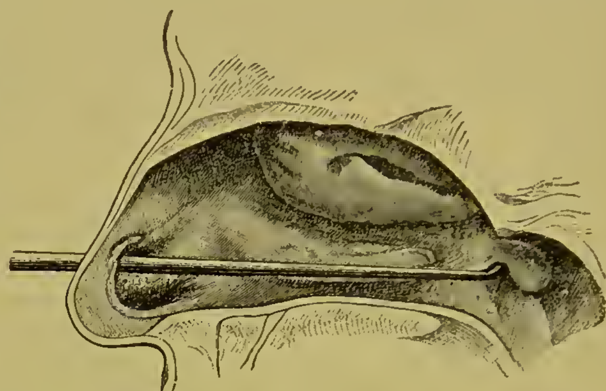


Fig. 264.—Catheterization of the Eustachian tube.

What are the indications that the catheter lies properly in the Eustachian tube?

After suceessful catheterization of the tube the ring of the catheter, as has been said, must be directed toward the outer corner of the eye and the beak of the catheter is fixed so that it can neither be turned forward or backward nor any farther in an upward direction. Speaking and swallowing should not be interfered with by the catheter, and the latter moves when the patient swallows. Finally, surgeon and patient plainly hear in the tympanum the air blown into the catheter if the latter is in proper position.

In performing catheterization one must especially see to it that the catheter does not leave the floor of the nasal cavity and that it does not finally make its way into Rosenmüller's fossa instead of the tube.

In exceptional cases, where the introduction of the Eustachian catheter through the nose is impossible, catheterization of the tube may be undertaken from within the mouth.

Catheterization is of the greatest importance from a diagnostic and therapeutie standpoint. It makes possible one of the most important methods of examining the organ of hearing—viz., auscultation of the tympanum.

In auscultation of the tympanic cavity use is made of an India-rubber tube about seventy or eighty centimetres long and from eight to ten or twelve millimetres in diameter. The ends of this tube are introduced into the auditory canal of the physician and of the patient.

Inflation of the Typanum.—For blowing air into the catheter or through the Eustachian tube into the tympanic cavity, the so-called air douche, a simple India-rubber bag, is best, or a double bag. In place of this hand douche, a tread bag which lies upon the floor may be used. By means of the India-rubber bag the air is driven into the tympanic cavity in jerks. For a more powerful injection of air or for a constant air pressure of from three tenths to four tenths atmospheres within the middle ear, Schwartze recommends the compression pump after Tröltsch.

The tympanic membrane is set in motion by the air douche and caused to bulge outward in the direction of the auditory canal.

We will speak later of the therapeutic value of the air douche, especially for the removal of secretions in diseases of the middle ear.

The crepitant râles which are heard in the Eustachian tube and the tympanum of the patient in connection with the air douche are very different, according to the character of the disease. Under normal conditions a blowing noise is heard in the middle ear, in consequence of the friction of the air against the walls of the tube and the tympanic cavity. In case of catarrh of the middle ear one hears fine râles if serous fluid is present, whereas coarse râles indicate fluids of a thicker consistence in the tube and middle ear, and dry crackling râles indicate a tough exudative coating without much fluid, and are similar to the friction sounds heard in dry pleurisy. In case of perforation of the tympanic membrane one hears chiefly a characteristic sibilant or hissing râle—the so-called perforation râle. An experienced person can usually easily distinguish the nearer crepitant râles in the tympanic cavity from those in the Eustachian tube, which are more remote.

Fig. 265. — India-rubber bag for inflation of the tympanum.

Vertigo, nausea, and fainting should be mentioned as among the possible contingencies attending catheterization or the air douche. In case of pathological changes in the tympanic membrane (atrophy, thinning, softening), it may be perforated by too strong pressure. Traumatic emphysema of the pharynx may result from air becoming forced into the submucous cellular tissue after injury to the mucous membrane by the beak of the catheter or from ulceration. This traumatic emphysema of the pharynx usually disappears in a few days. If the emphysema extends to the entrance to the larynx and causes marked discomfort, Schwartze advises that the tense mucous membrane of the pharynx be superficially opened with the finger.

Schwartze mentions two deaths from œdema of the glottis or from compression of the entrance to the larynx in emphysema of the pharynx. If necessary, tracheotomy should be performed.

As substitutes for catheterization of the Eustachian tube and the air douche which is combined with it, we have the methods of Valsalva and Politzer.

Valsalva's method consists in forced expiration, the mouth and nose being closed. In this way the air in the middle ear is suddenly condensed and the tympanic membrane bulges outward in the direction of the auditory canal. In case of perforation of the tympanic membrane, exuded material may be

driven from the tympanum into the auditory canal. This method has, in general, but slight practical value.

Politzer's method, on the other hand, is widely used. It consists in lessening the resistance in the Eustachian tube by the act of swallowing, and then in compressing from the nose the air in the naso-pharyngeal space which is shut off by the act of swallowing. For accomplishing this, use is made of an India-rubber bag with a tube of the same material which is provided with an insertion piece shaped like an olive or an acorn and made of horn or wood (see Fig. 266). The latter is introduced into the nostril, which is then pressed air-tight over the insertion piece with the thumb and forefinger. While the patient swallows, the air is forced with the right hand out of the bag into the nasal cavity and on into the Eustachian tube. In place of the simple India-rubber bag, double ones are also in use. Politzer's method is of great value from a therapeutic standpoint. It is a very simple way of giving air douches.

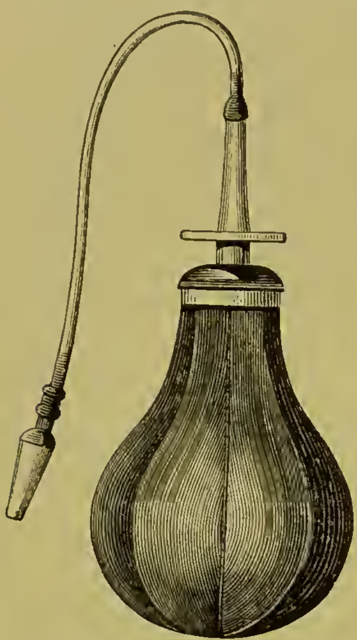


FIG. 266.—Politzer's inflation bag.

If the air douche meets with an obstruction within the Eustachian tube and is not heard at all in the tympanic cavity, a probe should be passed into the tube in order that one may inform himself with regard to its permeability.

Catgut is used for probing the tube, or laminaria bougies which swell up, and especially black bougies of the same material as the English urethral bougies. The latter are most frequently used and may be had in six different sizes.

For therapeutic purposes—e. g., in case of stenosis of the tube—the laminaria bougies are very serviceable. They are sterilized in a solution of carbolic acid before use, then besmeared with glycerin and introduced.

All these probes are introduced through the Eustachian catheter lying in the pharyngeal opening of the tube. Under normal conditions the probe makes its way easily as far as the isthmus of the tube, but generally meets with an obstruction here which may be overcome by moving it backward and forward and rotating it, so that it can then be very easily introduced as far as the tympanic opening of the tube. It must not be pushed beyond this. The probe must always be introduced very gently and cautiously, to prevent any injury.

In case of obstructions in the tube from pathological conditions the probe should not be forced in at a single trial, but should be introduced at intervals, and the attempt made to push it gradually and cautiously forward to the tympanic opening of the tube.

Posterior rhinoscopy, which has been more particularly described in § 39, pages 266–268, is indispensable in the diagnosis of diseases of the ear. By this method of examination various diseases of the naso-pharynx, especially in the neighbourhood of the tube, may be recognised.

Tests of the Hearing Power.—Finally, tests of the hearing power form one of the methods of examining the ear. The watch, speech, and the tuning fork are used in testing the hearing power of patients. Speech is most commonly employed in the form of whispered words. The other ear is of course to be closed. A striking disproportion is often observed between the distinctness with which the watch and whispered words are heard—e. g., whispering is heard from a much greater distance than the watch, or the reverse. The use of tuning forks for testing the conduction of sound through the bones of the head (cranio-tympanic conduction) is of great diagnostic importanee. After the tuning fork has been struck, its handle is placed upon different parts of the skull and the patient's perception of the tones determined for each ear. The tones of the tuning fork, for instance, are heard only or more distinctly in the ear that is alone or more seriously diseased, in case of defect in the apparatus for conducting sound. If, in case of deafness on one side, the patient hears the tones of the tuning fork transmitted along the skull only in the sound ear, the auditory nerve—that is, the perceptive part of the organ of hearing—is diseased. Complete deafness in one ear, in consequence of the loss of excitability of the terminations of the auditory nerve, surely exists if, for example, the handle of the vibrating tuning fork is firmly placed in the auditory canal of the deaf ear and the tone is heard only by the ear of the other side. From the examples that have been given it is clear that the use of cranio-tympanic conduction of sound by means of the tuning fork is, under certain circumstances, of great diagnostic value, and is useful in detecting simulation. To prove the latter, one may proceed as follows: In case of professed deafness in one ear the sound ear may be closed with cotton or with the finger and the vibrating tuning fork then placed upon the top of the patient's head. If the latter affirms that he does not hear the tone of the fork at all, not even in the ear that is closed, he is malingering. Schwartze gives various other methods for detecting simulation—the following, for example: The sound ear is plugged with cotton or with the finger, and if the patient asserts that he does not hear words spoken in a loud or only moderately loud tone, he is exaggerating or feigning his deafness. A double ear trumpet whose conducting tubes, when applied to the ears, are alternately eompressed or closed without the knowledge of the patient, is also effective. If complete deafness in both ears is feigned, proof of simulation is often difficult. Schwartze has also suggested several methods of procedure in this case. especially continued observation, chloroform narcosis, intoxication, addressing the patient as he awakes from sleep, etc. The chief thing in case of possible simulation is always a careful examination of the ear.

Ear Trumpets.—Intelligent deaf persons gradually learn better and better to infer the word from the movements of the lips of the speaker. To aid those who hear with difficulty, hearing apparatus and ear trumpets are in use. Duncker's ear tube, for instance, is especially servieeable. Dr. Aschendorf, of Wiesbaden, constructed an ear trumpet which sits firmly in the auditory canal and which Schwartze has described in the Deutsche Chirurgie, Lieferung 32, page 409. There are also apparatus for correcting an unfavourable position of the auricle. Many deaf persons help their hearing by plaeing the hand behind the auricle and bending it somewhat forward.

In case of loss of the auricle, otoplasty is indicated, or artificial ears of papier-maché, metal, or other material may be resorted to. If the conduction of sound is interrupted in the tympanum, an artificial tympanic membrane is often of use (see §§ 75, 76, Diseases of the Middle Ear).

§ 72. **Malformations, Injuries, and Diseases of the Auricle.**—We have already become acquainted in part with disturbances in the development of the auricle in our study of Malformations of the Face (see § 25, page 183). They are, for the most part, of no surgical importance.

I mention briefly here, in addition, absence of the auricle on one or both sides, partial defects in the same, congenital smallness (microty) and the opposite, abnormally large ears (macroty), which are occasionally observed in idiots. Double auricles have been repeatedly observed. Langer and Wilde, for instance, verified cases of four auricles. In Wilde's case two were in normal position and two were situated lower down on the neck. We mentioned on page 189 auricular appendages consisting of skin, subcutaneous cellular tissue, and cartilage, situated in front of the tragus, for instance, on the lobule of the ear or on the neck.

Stenosis and atresia of the auditory canal are often combined with branchial fistula of the neck, cleft palate, and semilateral atrophy of the face, and are conditioned upon disturbances attending the closure of the first branchial cleft.

Congenital fistula of the ear is to be regarded as a residuum of the first branchial cleft. The fistula lies, for the most part, in front of the ear above the tragus, or in the lobule. It is often bilateral and combined with fistulæ of the neck. A congenital fistula of the ear sometimes communicates with the middle ear or the pharynx.

The treatment of the malformations that have been mentioned is very varied. Some of them—such as the fistulæ, for example—require no special treatment.

In case of hypertrophy of the auricle, cuneiform pieces may be excised. Auricular appendages should also be extirpated if they occasion deformity. If the ears stand out noticeably from the head, the application of an elastic pad is to be recommended, or excision of a fairly long elliptical strip of skin along the insertion of the auricle with subsequent suture. In case of rigid cartilage, an elliptical piece of the same must be removed at the same time.

In congenital or acquired defects, or complete absence of the auricle, the attempt may be made to overcome the partial or total defect by means of a plastic operation.

Otoplasty.—The results of otoplasty are as yet altogether unsatisfactory, which is easy to understand, in consideration of the complicated

structure of the auricle. The new ear, which may be made by raising a flap of the skin lying behind the ear, always remains a shapeless lump of flesh. Kuhnt secured a good result in one case by the following method: He marked out a large flap shaped like the auricle, which included the remains of the cartilaginous auditory canal, and separated it from the skull down to the periosteum. He then cut two pedunculated tongue-shaped flaps, one from the cheek above and the other from the neck region below, which were turned down into the defect made by raising the flap that formed the ear in such a way that their epidermic surfaces were opposite the wound surface of the new auricle. The rest of the skull wound was covered by skin-grafting. The posterior surface of the ear was afterward covered with a flap from the upper arm, by which means it acquired sufficient thickness and more support.

Artificial ears of papier-maché or metal are often preferable to otoplasty, or the defect is concealed if possible by some method of arranging the hair. Single portions of the ear, on the contrary—the upper part, for instance, the border and lobule—can be well replaced by flaps taken from the immediate vicinity. After the flap has healed in place the pedicle is detached and the flap is then modelled by the excision of portions of skin and suture.

Injuries.—Owing to the exposed position of the auricle, injuries are not infrequent, especially those arising from cuts, stabs, punctures, shooting, and biting. Punctures arise most frequently from the use of earrings. Death even has occurred from gangrene of the ear and trismus (Hufeland and Altschul). Cicatricial keloid not infrequently results from such punctures in the lobule. The latter is sometimes cleft by tearing earrings out. This is easily remedied by freshening and suturing the edges of the cleft.

Partial detachments of the auricle generally heal very well if carefully sutured with antiseptic precautions.

If the auricle is entirely lost, otoplasty (see above) may be performed in suitable cases, or artificial ears of papier-maché or metal may be used, if the defect can not be hidden by arrangement of the hair.

The cicatricial contractions that sometimes occur after burning the ear are best prevented by transplantation of skin.

Subcutaneous injuries or contusions of the ear, arise from pulling upon the ear, kicks, blows, etc., and are attended with more or less effusion of blood, which, as a rule, gradually disappears.

Fractures of the elastic ear cartilage are, according to Schwartze, rare.

The othæmatoma (hæmatoma) of the ear is of special interest. The effusion of blood lies between the perichondrium and the cartilage,

most frequently in the concavity of the auricle. Othæmatoma is observed most often in the insane, especially in cases of paralytic dementia, but it also occurs in healthy individuals. There is not always a preceding traumatism. In cases that are not traumatic, it is caused by a degeneration of the cartilage of the ear, with softening and liquefaction of the ground substance, and with secondary hæmorrhage. Similar blood effusions occur also in the nasal cartilage (nasal hæmatoma). The effusion of blood is gradually absorbed, and this is often attended by its calcification. Inflammation and suppuration seldom occur.

Schwartze recommends, in accordance with W. Meyer's suggestion, the use of bandages that exert pressure, and massage, in cases of othæmatoma, in order to accelerate the absorption, and so far as possible to avoid deformity of the auricle. If necessary, the effusion may be removed by aseptic incision, with subsequent aseptic dressing.

Inflammations of the Auricle are similar to those that occur in other parts of the surface of the body. Acute and chronic eczema is somewhat common, especially in children with otorrhœa. In very chronic cases these eczemata lead to hypertrophy and deformity of the auricle, and sometimes involve the auditory canal, so that—very rarely indeed, to be sure—erosion and perforation of the tympanic membrane occur.

The treatment of eczema of the auricle is the same as for ordinary eczema of the skin—viz., unguentum diachylon and powdering with amylum and zinc oxide (equal parts, or 5 to 1). Any crusts that may be present should be softened beforehand with olive oil and lukewarm water. The more the eczema is protected from moisture the more quickly it heals. Oleum rusci also and occasional cauterization with nitrate of silver in solid form or in solution are advantageous.

Eczema of the auditory canal is also treated with unguentum diachylon or salicylic ointment. Dusting powders are to be avoided in case otorrhœa exists, as they cause retention of pus in the tympanic cavity.

In every case of eczema the otorrhœa must be treated according to general rules (see § 76, pages 464, 465 ff., Diseases of the Tympanic Cavity).

Phlegmonous inflammations of the auricle occur especially after traumatism. They seldom terminate in gangrene. The treatment follows general rules—ice externally, incisions, etc. In the application of ice, the auditory canal is to be carefully closed with cotton, as otherwise inflammation of the middle ear may easily occur.

Acute and chronic inflammation of the perichondrium sometimes leads to exfoliation of the cartilage; not extensively, however, as a rule, so that disfiguration of the auricle does not result. Chronic perichon-

dritis is sometimes tubercular. Primary, acute, and chronic forms of perichondritis are characterized by swelling of the auricle, with only slight involvement of the skin.

The treatment of acute and chronic perichondritis conforms to general principles. Ice, for example, is used in acute perichondritis, and warm poultices in the chronic form. In case of fluctuation, or even earlier, an incision should be made, and in case of tuberculosis the sharp spoon is used.

Inflammation sometimes results from freezing the auricle, which often continues during one's whole life, being especially noticeable during the change from cold to warm weather. In a warm room or in summer there is itching, with the formation of nodules and hyperæmia, going on to the formation of vesicles and ulcers. For these inflammations after frostbite, tincture of iodine, solution of gutta-percha in chloroform, and injection of ergotine or absolute alcohol are to be recommended. Ulcers are treated according to general rules.

Neuroses of the auricle are very rare, according to Romberg and Schwartze. Isolated spastic contractions of the auricle have been observed, the other parts supplied by the facial nerve not participating. In such cases both ears are drawn up and down with great rapidity for from five to ten minutes. Wolff saw tonic spasm of the auricle in which it was bent backward. Neuralgia, itching, and anæsthesia have been observed—e. g., in deafness due to a central cause.

Tumours of the Auricle.—Fibromata occur on the auricle especially in the form of cicatricial keloids in connection with punctures of the lobule. Chondromata, lipomata, myxomata, and sarcomata have been very seldom seen, angeiomata somewhat oftener. Cirsoid aneurism also occurs on the posterior auricular artery, and such patients are tormented by sounds in the ear. Epitheliomata of a nodular or ulcerating form are not uncommon.

Among cystic tumours of the auricle, the dermoid cysts filled with epidermis and hair, which arise from an inversion of embryonic skin, are worthy of notice. They are caused by disturbances of development in the vicinity of the first branchial arch. Their favourite place is in front of the ear, in the temporal region, or behind the ear. Retention tumours or cysts are also to be mentioned, especially those of the sebaceous glands (atheromata), which are fairly common. Gummata also have been occasionally seen on the auricle.

The removal of tumours of the auricle conforms to general rules. In case of angeioma, repeated punctures with Paquelin's thermo-cautery are to be recommended, with ligation of the afferent vessel if necessary. The surest step is always extirpation of the angeioma if it

is possible. The same course is to be pursued in case of cirsoid aneurism, together with ligation of the afferent vessel, or of all the branches supplying this area.

§ 73. **Malformations, Injuries, and Diseases of the External Auditory Canal.**—Among disturbances in the development of the external auditory canal I will mention especially congenital atresia, which is usually combined with malformation of the auricle and tympanic cavity. In congenital atresia either a blind cartilaginous auditory canal, closed by a membrane or bone, is found, or instead of the auditory canal there is a compact mass of bone which frequently has a depression in the place of the external opening. In a third class of cases the auditory canal is obliterated by an abnormal growth of the soft parts.

It may also happen that there is only an apparent obliteration of the auditory canal, inasmuch as a small canal leads from the latter to the tympanic membrane; or, finally, there is only a narrowing of the auditory canal, caused by a projecting membrane in the form of a ring or partition. Those cases only admit of operative treatment in which the auditory canal is closed by a growth of skin from both sides. In such cases the skin is either excised in a circular form or simply divided and laminaria inserted. In case of stenosis of the canal, dilatation should be carefully undertaken.

Injuries of the auditory canal are as a rule without danger, provided the tympanic membrane and the internal parts of the organ of hearing are not harmed. Serious complications are, however, possible even after injury to the auditory canal alone, especially cellulitis, periostitis, secondary disease of the mastoid process, and, in exceptional cases, death from suppurative meningitis.

Fractures of the bony wall of the auditory canal are most frequent in the anterior portion, in consequence of a blow or a fall upon the chin, and are combined with fracture of the glenoid cavity of the temporal bone. In case of the action of great violence the condyloid process of the inferior maxilla may be displaced into the middle fossa of the skull. Fractures of the upper and posterior walls of the auditory canal are not infrequent in cases of fracture of the base of the skull. If, in such fractures, the dura is torn, as is usually the case, cerebrospinal fluid and even brain substance escapes from the ear. If blood flows from the ear, a careful examination of the auditory canal should always be made with reference to the presence of a fracture. If the skin lining the auditory canal is not broken in connection with the fracture, bleeding may not occur.

For a more detailed description of fractures of the base of the skull the reader is referred to § 9, page 56 ff. See also § 46, pages 309, 310.

The treatment of wounds of the auditory canal is conducted according to antiseptic rules, in order to avoid secondary progressive inflammation and suppuration. Boric-acid powder, iodoform, and sterile cotton may be inserted into the canal. With reference to the removal of foreign bodies, see § 74, page 63. The treatment of fractures of the bony auditory canal has already been given in connection with fractures of the base of the skull (page 63), and in connection with injuries of the temporo-maxillary articulation (pages 269, 270).

Among inflammatory processes in the auditory canal the furuncle is the most common. It is found especially on the anterior and inferior walls of the cartilaginous canal, and is characterized by a circumscribed and very painful swelling. The auditory canal is sometimes so contracted that the recognition of the furuncle is difficult for the inexperienced observer, and it is easily mistaken for secondary abscess of the auditory canal, following suppuration of the middle ear. After opening the furuncle, or after spontaneous escape of the pus, the pain usually disappears at once. Their course is sometimes prolonged and very painful, inasmuch as one furuncle follows another.

Simultaneous inflammation of the tympanic cavity frequently accompanies a furuncle of the external auditory canal.

Extensive phlegmonous inflammation, and even fatal thrombo-phlebitis and pyæmia, have been observed, in rare cases, to follow a furuncle. The treatment of a furuncle of the external auditory canal is by prompt incision, especially if the pain and swelling are severe. After incision the pain soon ceases. Wet dressings are also serviceable, and the auditory canal may be plugged with cotton and vaseline or boric acid, bismuth, or oxide of zinc. Poultices are to be discarded. Irrigation with a lukewarm solution of boric acid must be done only with care. In case of chronic, recurring furunculosis, Schwartze recommends bathing the ear with a lukewarm one-per-cent solution of potassium sulphate once or twice daily, for half an hour at a time, during the absence of acute symptoms.

Cholewa recommends the introduction of pieces of cotton soaked in a twenty-per-cent solution of menthol in cases of furunculosis of the external auditory canal. They should exert only slight pressure.

When the furuncle is deeply seated, and treatment by incision is difficult, Grosch recommends dropping acetate of aluminium, diluted four times, into the auditory canal. The latter is filled with the solution every hour and plugged with cotton.

In case of stricture of the auditory canal after healing of the incisions, the introduction of small cylindrical sponges is to be recommended.

Diffuse inflammations of the external auditory canal, from a superficial erythema to the deep-seated phlegmon (otitis externa phlegmonosa), with suppurative periostitis, not infrequently follow injuries which are not treated antiseptically. Sometimes we have to do with a genuine erysipelas. According to the location and the degree of the inflammation, hyperæmia and swelling of the external auditory canal take place, and sometimes to such a degree that the membrana tympani is no longer visible, and one can determine nothing regarding its condition and that of the tympanic cavity. The subjective symptoms consist of pain, tinnitus aurium, and impairment of hearing, varying according to the degree and the extent of the inflammation. The inflammation often gradually subsides without suppuration. If suppuration occurs, rapid recovery usually follows. There are, however, very malignant cases of deep, rapidly spreading phlegmon, followed, it may be, by gangrene, and death from sepsis, meningitis, and purulent sinus thrombosis. As subcutaneous cellular tissue is wanting in the osseous auditory canal, the inflammation is here essentially a periostitis which may extend to the bone and the mastoid process and lead to necrosis.

Perichondritis of the cartilaginous auditory canal corresponds to periostitis of the osseous auditory canal. Suppurative forms, with necrosis of the cartilage, occur here also, and sometimes run a very chronic course.

Suppurative inflammations of the external auditory canal sometimes lead to the formation of polypous proliferations of granulation tissue, and by perforation of the tympanic membrane the middle ear becomes involved. Treatment must therefore be prompt and energetic.

The prognosis of diffuse inflammations of the external auditory canal is, in general, favourable, death from meningitis or sinus thrombosis occurring only as a rare exception.

In mild cases special treatment is unnecessary. For alleviating pain, leeches may be applied in front of the tragus, and internally morphine in small quantities every hour. In case of severe inflammation, including phlegmon, periostitis, or perichondritis, incisions must be made as early as possible, even before suppuration begins, and use then made of antiseptics for irrigating the auditory canal—e. g., three-per-cent boric acid, 1-to-100 carbolic acid, or 1-to-5,000 bichloride. The ear is packed with absorbent iodoform gauze. Too abundant use of powders in the auditory canal is to be avoided on account of the danger of retention of pus. Any secondary conditions are to be treated in accordance with general rules. Polypous proliferations of granulation tissue are to be removed with Wilde's snare, and the pedicle of the

granuloma may be cauterized with the nitrate-of-silver stick. Strictures are dilated by means of cylindrical compressed sponges to which a loop of thread is attached.

Ulcers of the auditory canal result from superficial erosions, from suppuration with sloughing, or from eczema. Deep ulcers occur in connection with carcinoma, syphilis, diphtheria, and tubercular disease of the soft parts and the bone. Diphtheritic ulcers of the auditory canal occur most frequently in connection with diphtheria of the throat, but may also appear independently if from any cause a circumscribed area has been denuded of its epidermis.

After the healing of deep ulcers of the auditory canal, cicatricial contractions and adhesions occur.

The treatment of ulcers of the auditory canal is directed against their cause. Superficial ulcers from erosion heal rapidly by cauterization with the nitrate-of-silver stick, painting with the nitrate of silver in solution, and the insertion of iodoform gauze or cotton moistened in lead water. Deeper tubercular ulcers should be thoroughly scraped with a sharp spoon. Syphilitic ulcers may be healed by energetic cauterization with the nitrate-of-silver stick and general antisyphilitic treatment (inunctions, mercury hypodermically, iodide of potassium ; see Principles of Surgery, § 84). For diphtheria of the auditory canal, Gottstein recommended as a means of loosening the membrane bathing the ear with limewater for fifteen minutes at a time and irrigating it with one-per-cent solution of carbolic acid, and, finally, insufflating iodoform, boric acid, or salicylic acid.

Carcinomatous ulcers should be extirpated as soon as possible (see page 458, New Growths).

In consequence of abundant secretion of the sweat glands and sebaceous glands of the auditory canal, the condition known as impacted cerumen may occur. The mass consists of the secretion of these glands, epidermis cells, small hairs, and cholesterine crystals. A foreign body which has entered the auditory canal sometimes forms the nucleus. Many persons have a tendency to the formation of these impacted masses of cerumen and are frequently obliged to have them removed. They fill the auditory canal more or less completely, but usually lead to no secondary conditions other than that the patients hear with difficulty, and frequently suffer from tinnitus aurium, a feeling of heaviness in the head, and vertigo. The skin of the auditory canal sometimes undergoes a softening process, and secondary inflammation may ensue. Atrophy and erosion of the tympanic membrane occasionally occur as a result of these impacted masses, and the membrane may become adherent to the inner wall of the tympanic cavity.

There also occur in the auditory canal, in exceptional cases, concretions made up of the carbonate and phosphate of lime, similar to rhinoliths.

The diagnosis of impacted cerumen in the auditory canal is easy. One finds, upon examination, typical masses, for the most part black or blackish-brown, by which the tympanic membrane is usually completely hidden. The plugs sometimes protrude so far that they are seen without an ear speculum by simply drawing the auricle backward and upward. They may possibly, however, be confounded with blood-clots and inspissated pus.

The treatment consists in removal of the masses by irrigating the canal with lukewarm water. If the masses adhere very firmly, softening solutions are dropped in (carbonate of potash 1 to 60 or 1 to 30, caustic potash or caustic soda 1 to 120) and the auditory canal is again irrigated with lukewarm water. These irritating solutions must not be allowed to act too long for fear that they may gain access to the tympanic cavity through a possible defect in the tympanic membrane, and so occasion inflammation. They cause the masses to swell, and the discomfort is thus temporarily increased, only to disappear entirely, as a rule, after the plugs have been removed. If this relief is not afforded there exists, not infrequently, some complication in the tympanic membrane, the middle ear, or the nerve apparatus of the ear.

New Growths in the Auditory Canal.—Among new formations in the auditory canal, polypous growths are common either in the form of granulomata or papillomata (warts). Granulomata, or so-called polyps of the auditory canal, are usually combined with polyps of the tympanic cavity, and are a frequent result, as is well known, of chronic suppuration of the middle ear. In rare cases, enchondromata, angeiomata, sarcomata, atheromata, and carcinomata occur in the auditory canal. Broad syphilitic condylomata are also sometimes observed in the auditory canal, accompanied by inflammatory symptoms and severe pain. The occurrence of primary cholesteatomata of the auditory canal is doubtful, according to Schwartze. They originate, for the most part, in the tympanic cavity or the mastoid antrum. Exostoses are the most common tumours, and are found especially on the posterior upper wall at the beginning of the bony auditory canal, or just in front of the tympanic membrane.

The treatment of tumours of the auditory canal conforms to general surgical principles. Their removal is especially indicated when real discomfort exists, or the auditory canal is filled by the neoplasm, or if, in case of suppuration in the middle ear, retention of pus is threatened. In the latter case they should be removed without delay. Polyps of the auditory canal, which are so common in connection with suppuration of the middle ear, aside from operative removal by means of a polyp snare, may also be gradually removed, by the use of arsenious acid in the form of a paste (Whittelt). Exostoses are best removed by means of a chisel, with detachment of the auricle and cartilaginous auditory canal from behind, if necessary, the same being reflected forward. A very fine gouge is used, which, if circumstances require, may be bent or provided with a handle which diverges at an acute angle.

§ 74. **Foreign Bodies in the Auditory Canal and in the Tympanic Cavity.**—Foreign bodies are not infrequently found in the ear, and for the sake of simplicity we will here consider together foreign bodies in the auditory canal and in the tympanic cavity.

These bodies are found especially in the auditory canal of children, and they may, particularly as a result of careless attempts at extraction, gain access to the tympanic cavity after perforation of the tympanic membrane. They may also pass through the Eustachian tube into the tympanum. The presence of foreign bodies in the tympanic cavity is always to be regarded as a serious matter, as severe inflammation may result. Such a body sometimes remains here a long time without injurious effects, but this is exceptional. It is, however, not at all a rare occurrence for these bodies to remain for years in the auditory canal without the knowledge of the patient. Schwartze removed the head of a lead pencil from the auditory canal which had lain there ten years, and I removed a bead which had been introduced into the ear eight years before. In exceptional cases severe symptoms result—e. g., neuroses and epilepsy.

The foreign bodies most frequently found are beans, peas, pebbles, beads, bits of wood, etc. Forms of animal life also, especially living and dead insects as well as the larvæ of flies, are occasionally found in the ear. Of living things, the flea is most often found, which is said to produce a great noise by jumping upon the tympanic membrane. The larvæ of flies are occasionally found in great numbers in connection with offensive suppuration of the ear in children, and occasion severe pain, and not infrequently delirium.

Among vegetable parasites mould fungi are especially to be mentioned. This so-called otomycosis often gives rise to very obstinate inflammations of the auditory canal, the tympanic membrane, and, it may be, of the middle ear. It is also attended with unbearable itching.

Owing to the growth of mould fungi (otomycosis) patchlike colonies are usually observed in the form of light- or dark-coloured aggregations, especially on the tympanic membrane. Dark-red fungous growths also occur (otomyces purpureus). A microscopic examination of the coating is usually necessary, however, to make sure the diagnosis.

The diagnosis of foreign bodies is easy for any one who is familiar with the examination of the ear except when the body is hidden by an extravasation of blood or swelling of the auditory canal, or when the same has been driven, in consequence of careless attempts at extraction, into the tympanic cavity after perforation of the tympanic membrane.

The treatment in these cases consists in removal of the foreign body by syringing the canal with lukewarm water. A warning should be given against extraction with instruments, inasmuch as the object is not usually accomplished in this way, and especially because the condition of things is often made worse. Injuries to the tympanic mem-

brane and the internal ear, suppuration, and even meningitis and abscess of the brain, have not infrequently been caused by the use of instruments.

If syringing with lukewarm water is not successful in removing the body, extraction with instruments must be resorted to, but great caution is necessary. Only instruments of such a kind should be used as can be passed behind the foreign body—e. g., a curette, a small blunt hook, a Wilde's snare, a loop of silver wire, or small forceps. Straight forceps, which can not be properly opened to seize the body, are useless. Swollen beans or peas may be advantageously broken up into pieces and then syringed out. If the attempts at extraction do not succeed, and inflammation already exists, it is better to wait till the swelling and inflammation are reduced. Should fever, headache, and delirium—symptoms, in short, of threatening brain trouble—appear, operation must immediately be resorted to. Schwartze recommends detaching the auricle by a curved incision behind the same, close to its insertion, and entering the auditory canal near the junction of its cartilaginous and bony portions. Extraction of the foreign substance is then, as a rule, easily accomplished by means of a bent dressing forceps, a sharp spoon, or other leverlike instrument.

If the body is in the tympanic cavity, syringing is usually of no use, and removal is then best accomplished by the air douche (see above, page 447), or by injection of water through the Eustachian tube, or by operation. Operative measures consist in detaching the auricle with or without extirpation of the membranous lining of the posterior bony wall of the auditory canal, or with chiselling away of this wall, opening, if necessary, the mastoid antrum and removing the pars epitympanica of the upper wall of the bony auditory canal (Zaufal).

Foreign bodies in the mastoid process are renewed by trephining the latter (see page 479).

If there are symptoms of abscess of the brain, the cranial cavity is to be opened and a search made for the foreign body. Any neighbouring thrombosed sinus is also to be opened.

The body temperature and the results of an ophthalmoscopic examination are, according to Zaufal, the chief considerations in determining the necessity of operative interference in dealing with foreign bodies—e. g., in the tympanic cavity. One can judge by means of the ophthalmoscope how far the brain membranes have already shared in the inflammation. If there is pronounced neuroretinitis or choked disk, there should be no delay in undertaking the operation.

Live animate bodies are removed by syringing with lukewarm water, or they may be smoked out or killed by tobacco smoke or by

chloroform dropped on cotton. Syringing is usually without effect in case of the larvæ of flies, and their removal is best accomplished, according to Heine, by filling the auditory canal with oil. The larvæ then creep out, of their own accord, to breathe, and they can then be removed with small forceps.

For otomycosis Schwartze recommends dropping a six-tenths-per-cent solution of permanganate of potash into the ear after it has been syringed out and plugging the auditory canal with cotton impregnated with boric acid. Theobald recommends insufflation of oxide of zinc and boric acid in equal parts. Blake recommends natrium subsulphurosum (0·13 gramme to 30 grammes of water). Treatment has often to be continued for from five to eight weeks, and even longer, before a permanent cure is obtained.

§ 75. **Malformations, Injuries, and Diseases of the Tympanic Membrane.**—Among disturbances in the development of the tympanic membrane, anomalies of inclination, form and size, are to be mentioned first. A strikingly perpendicular position of the membrane is most frequently observed in people of special musical ability.

Congenital absence of the tympanic membrane is very rare, and, when found, is usually combined with a defect in the bony auditory canal. Membranous new growths in the vicinity of the tympanic membrane may give rise to the false impression that there are two membranes. Arrested development in the form of a persistent opening (foramen Rivini) occurs in rare cases.

Fig. 267.—Double rupture of the right tympanic membrane caused by a fall on the ear (Politzer).

Of injuries to the tympanic membrane, ruptures are especially important, which either result from direct violence—e. g., from pointed foreign bodies—or are caused indirectly by a blow, a kick, or concussion of the head or bones of the skull, with or without fracture of the temporal bone. Boxing the ears is the most prolific cause of indirect ruptures of the tympanic membrane.

The location, size, and form of the ruptures (see Fig. 267) are naturally very variable. As a result of slight direct or indirect injuries to the tympanic membrane, excoriations or extravasations of blood in the substance of the tympanic membrane occur.

The symptoms of rupture of the membrane are in part subjective and in part objective. The principal subjective symptoms, particularly if the membrane is normal, is severe pain. If the membrane has undergone pathological change—e. g., atrophy and fatty degeneration—the pain is less severe. Aside from the pain, symptoms of concussion of

the brain are frequently present—e. g., vertigo, fainting, vomiting, and convulsions. In addition, the hearing is impaired. Patients sometimes hear or feel a distinct crackling sound at the moment the rupture takes place.

Upon examination of the tympanic membrane one sees distinctly, besides the hæmorrhage, the site of the rent. Its edges are usually covered with blood. When the patient blows forcibly, and when the air douche is employed through the Eustachian tube, one hears a distinct sibilant perforation râle.

The prognosis of ruptures of the tympanic membrane is favourable. If the tympanic cavity or the nerve terminations have not suffered in consequence of the injury, entire recovery follows in a few days or, less frequently, in a few weeks. Suppuration sometimes occurs, however, after such a rupture, and in rare cases death ensues from suppurative meningitis, especially in case the treatment is not of the right sort or the patient seeks medical aid too late.

Of the complications of rupture of the tympanic membrane, by which the prognosis is made less favourable, there should be mentioned especially injuries to the tympanic cavity, displacement of the ossicles, fracture of the manubrium of the malleus (see Fig. 268) or the stapes, and, lastly, fracture of the base of the skull and injury to the internal organ of hearing.

Fig. 268.—Fractured manubrium of the malleus (Schwartze).

The treatment of rupture of the tympanic membrane consists especially in complete rest, as in every case of injury to the head, in avoiding alcohol, and in attention to regular movements of the bowels. All congestion of the head is to be strictly avoided. The auditory canal should be hermetically closed with aseptic cotton. Syringing and the air douche should not be employed. In case of inflammatory symptoms a few leeches in front of the tragus and active catharsis are to be recommended. Complications are to be treated in accordance with general rules (see treatment of suppuration of the tympanic cavity, of fractures of the base of the skull, etc.).

Inflammations of the Tympanic Membrane are very frequent. They are seldom primary, but for the most part secondary to inflammations of the tympanic cavity or the auditory canal.

Acute inflammation of the tympanic membrane (myringitis acuta) consists partly in the formation of a circumscribed serous or purulent exudate (Fig. 269), but more frequently in diffuse inflammation, usually in consequence of concussion, or from the action of fluids that are either irritating,

too hot, or corrosive. The symptoms of acute inflammation of the tympanic membrane are pain, a feeling of pressure in the ear, tinnitus aurium, and the like. On examining the membrane, hyperæmia is found at first, especially in the vicinity of the manubrium of the malleus. The latter is indistinct, and the membrane is flattened out in consequence of being filled with serum. In the later stages there are ecchymoses, abscesses, and, it may be, perforations. Bulging of the tympanic membrane in consequence of a serous exudation or abscess may be easily mistaken by the inexperienced for bulging of the membrane from exudations within the tympanic cavity. The hearing is but slightly impaired when the tympanic membrane alone is diseased. The further course is generally favourable. The serous exudation is absorbed, the abscess breaks externally and forms a corresponding ulcer of the tympanic membrane, or there ensues a complete perforation of the membrane toward the tympanic cavity and toward the auditory canal.


FIG. 269.—Abscesses within the membrana tympani (Schwartze).

After an acute myringitis has healed, thickening of the tympanic membrane often persists for a long time. When suppurative myringitis is complicated with suppuration within the tympanic cavity, death may ensue from meningitis or sinus thrombosis.

Treatment of Acute Myringitis.—In the beginning leeches are applied in front of the tragus, complete rest is prescribed, all congestion of the head is avoided, and cathartics are given. In severe cases attended with marked inflammatory swelling, paracentesis of the tympanic membrane (see pages 474, 475) is indicated. The course of the disease is in this way decidedly shortened, and ulceration is prevented. Circumscribed abscesses are likewise opened by the point of a knife. In case of suppuration or ulceration on the surface of the tympanic membrane, mild astringents are serviceable. Complicating catarrh and suppuration of the middle ear receive their usual treatment (see page 466, ff.).

Chronic inflammation of the tympanic membrane (myringitis chronica) is more common than the acute form. It sometimes follows the acute form, but may be chronic from the beginning. From an anatomical and clinical standpoint various forms are distinguished, the most common being serous, suppurative, and dry or desquamative inflammations. In the latter form (myringitis sicca), which is a very obstinate and frequently recurring inflammation, an indurated lamellar thickening of the epidermic covering of the tympanic membrane is found. Papillary growths on the outer surface of the membrane, with new growth of connective tissue in the latter, are sometimes observed (myringitis villosa, Nassiloff).

Chronic inflammation of the tympanic membrane terminates in induration, opacity, deposits of lime, atrophy, and flattening, or finally in ulceration and perforation.

The treatment of chronic inflammation of the tympanic membrane consists in the application of astringents (sulphate of zinc, lead acetate). In case of superficial suppuration, Schwartze recommends painting the membrane with chromic acid, fifty per cent in distilled water. Ulcers of the

membrane are cauterized with nitrate of silver or sulphate of copper. Granulomata are removed by the use of Wilde's snare. In case of indurative and desquamative myringitis, the thickened epidermis is carefully removed with small forceps after it has been softened with alkaline solutions. The corium of the tympanic membrane is then painted with a one- to two-per-cent solution of nitrate of silver (Schwartze).

Tuberculosis of the tympanic membrane is characterized by the formation of yellowish-red spots as large as the head of a pin in persons who are otherwise tuberculous, and especially those who have tuberculosis of the lungs. In such cases rapidly progressing cheesy and purulent destruction of the tympanic membrane is sometimes observed, and the latter does not become regenerated. As a rule, the tympanic cavity is the seat of tubercular disease at the same time. The prognosis of tuberculosis of the tympanic membrane is, according to Schwartze, very unfavourable, as most patients thus afflicted die within the next six months.

The treatment is directed principally against the pulmonary phthisis that exists at the same time. Cleansing and disinfecting injections are made locally.

New growths on the tympanic membrane are without special practical significance. Telangiectases, cysts, and cholesteatomata (Wendt) are sometimes observed. One finds occasionally in large numbers, both on the external cutaneous and the inner mucous surface, shining, white, pearl-like nodules, from the size of a millet grain to that of the head of a pin, arising from proliferation of the epithelium with inclosed cholesterin—very small cholesteatomata, as it were.

§ 76. **Malformations, Injuries, and Diseases of the Tympanic Cavity.**—We have already mentioned malformations of the tympanic cavity (§§ 72, 73, 75). They are without surgical importance.

Injuries of the tympanic cavity arise from hot, boiling, or corrosive fluids, and from foreign bodies of the greatest variety that have entered it, especially from the auditory canal after perforation of the tympanic membrane. These injuries of the tympanic cavity involve in part the mucous membrane, the muscles, and nerves, especially the chorda tympani, and may include fractures of the ossicles and separation of the articulations, particularly between the incus and stapes. Suppurative inflammation of the tympanic cavity very frequently develops after such injuries, with subsequent permanent impairment of hearing. As a result of indirect violence—for example, a fall or blow upon the head—effusions of blood into the tympanic cavity may occur (hæmatotympanum), with or without rupture of the tympanic membrane. Hæmatotympanum is also observed occasionally after too energetic an air douche, after violent coughing—whooping-cough, for instance—or after vomiting (Schwartze). Finally, injury of the tympanic cavity in connection with simultaneous fracture of the base of the skull should also be mentioned.

The treatment of injuries of the tympanic cavity consists in occlusion of the ear with aseptic cotton or iodoform gauze, in rest, and in the avoidance of congestion of the head. In case of severe pain, leeches are serviceable and a cathartic may be given. All active treatment should at first be avoided, especially injections into the ear. As soon as inflammation of the tympanic cavity appears it is to be treated in accordance with general principles (see page 466).

Acute serous inflammation of the tympanic cavity—that is, acute inflammation with increased production of mucus—is a very common disease, which occurs particularly among children in connection with a cold in the head or sore throat, and in the course of an acute exanthema, typhoid, etc.

The symptoms of simple acute serous inflammation of the tympanic cavity are pain of very variable intensity, impairment of the hearing, which is noticeable very early, a feeling of pressure and weight in the head, vertigo, noises in the ear, and often tenderness over the mastoid region. There is sometimes fever as high as 40° C. (104° F.), together with delirium. If the hyperæmia and inflammation extend to the neurilemma of the facial nerve in the aquæductus Fallopii, facial paralysis may ensue. So called rheumatic facial paralysis has in some instances such an origin as I have shown in a monograph on this subject (Ueber Facialislähmung bei Ohr-Krankheiten). Involvement of the sheath of the facial nerve in acute inflammations of the tympanic cavity is favoured by congenital fissures, which are not infrequently present in the wall of the aquæductus Fallopii.

The anatomical changes in acute catarrh of the tympanic cavity consist of hyperæmia and swelling of the mucous membrane of the tympanum and of the tympanic membrane, with a serous exudate varying in amount. Sometimes the exudate is sero-sanguineous.

The clinical course of acute serous inflammation of the tympanum is for the most part favourable, especially if the case has prompt and proper treatment. A perforation of the tympanic membrane is exceptional and usually heals quickly. If not treated at all, or improperly, the acute inflammation very often passes over into the chronic form, and corresponding changes in the tympanic cavity, with permanent impairment of hearing, follow, especially thickening of the mucous membrane, cordlike adhesions, deposit of lime salts, rigidity of the ossicles, etc. The condition of the naso-pharynx is very important in connection with the course of an otitis media that has become chronic. If there exists at the same time a chronic naso-pharyngitis, the inflammation of the tympanic cavity takes also a protracted course.

The diagnosis of acute serous inflammation of the tympanum is based, above all, upon what is ascertained by otoscopy, by testing the hearing power, and by auscultation after catheterization of the Eustachian tube. Upon examination with the ear speculum, the tympanic membrane at the beginning of the disease is found to be more opaque than normal, because the reflection of light is less distinct in consequence of serous exudation into the membrane. Later there is engorgement, particularly in the vicinity of the malleus vessels, or the hyperæmia may be more diffuse. As a result of the

exudate, the membrane bulges outward in parts, or, in case of much exudation, *in toto*. The hearing power is more or less impaired. Upon giving the air douche through the catheter that is introduced into the Eustachian tube, one hears, according to the amount and the character of the exudate, fine or coarse moist râles or crepitant râles (see page 447). In case of marked swelling of the tympanic cavity or very thick mucus, the râles may be more or less completely absent.

The treatment of acute serous inflammation of the tympanic cavity depends partly upon the degree of the inflammation. It consists at first in general dietetic measures, in diaphoresis, and in active catharsis. From three to six leeches are applied in front of and behind the ear. It is often necessary to keep the patient in bed. After the pain has ceased, the air douche through the ear catheter, or by Politzer's method, is made use of to aid the absorption of the exudate, and to prevent the adhesion of portions of the mucous membrane that are in contact. The air douche is used daily at first, and then less often, until no râles are to be heard. In case of more abundant exudation with corresponding bulging of the tympanic membrane, paracentesis of the latter is indicated. This is, if necessary, to be repeated, especially in case of a thick, mucous exudate (see pages 474, 475). If there is marked swelling with a small exudate, Schwartze recommends calomel (0·06 to 0·012 grammes three times a day) until salivation is produced.

Attention must always be paid to the condition of the nose and pharynx during acute inflammation of the tympanic cavity.

After recovery from acute serous inflammation patients must guard as carefully as possible against taking cold.

Chronic serous inflammation of the tympanic cavity is a very common disease, and the most frequent cause of deafness. It either results from recurring acute serous inflammation or begins very gradually in the chronic form. Chronic inflammation of the naso-pharynx, congestion resulting from disease of the heart and lungs, tuberculosis, etc., play an important part in the etiology of chronic catarrh of the tympanic cavity.

The anatomical changes found in chronic serous inflammation of the tympanic cavity are hyperæmia and hypersecretion of the mucous membrane in varying degree, shrinkage, thickening and sclerosis of the mucous membrane, adhesions, rigidity of the articulations between the ossicles, thickening and lime deposits in the tympanic membrane, etc.

The chief symptom of chronic serous inflammation of the tympanic cavity is deafness, which is sometimes greater and sometimes less, but which constantly increases. Pain occurs especially during acute exacerbations of the disease. Attacks of vertigo and very troublesome noises in the ear sometimes occur.

The tympanic membrane is usually found, upon examination, to be thick-

ened and of dull appearance and to have undergone changes, especially in its colour and convexity. In case of abundant exudation, it bulges outward in parts or as a whole, or, on the contrary, it may be retracted, as the result, for instance, of protracted closure of the Eustachian tube, or from shortening of the tendon of the tensor tympani muscle.

On the application of the air douche through the catheter it is found that the entrance of the air is delayed, and that there are more or less numerous râles.

The prognosis of chronic serous inflammation of the tympanic cavity is the more favourable the earlier suitable treatment begins. The general condition of the patient has an important bearing upon the prognosis. If constitutional diseases, particularly tuberculosis and syphilis or heart and lung lesions, already exist, the prognosis is unfavourable.

The treatment of chronic serous inflammation of the tympanic cavity is partly of a local and partly of a constitutional character. Local treatment consists especially in the frequent use of the air douche through the catheter. In milder cases, or when the Eustachian tube is closed, Politzer's method is used. Striking improvement in the hearing power is usually secured in this way, and the patient is relieved. In addition, medicaments in the gaseous or fluid form may be forced through the catheter into the tympanic cavity. If, for instance, the secretion is thick and abundant, and the swelling of the mucous membrane of the Eustachian tube is very marked, vapours of chloride of ammonia, formed from crude hydrochloric acid and caustic ammonia, may be employed (Schwartze), or steam at a temperature of 30° to 40° R. (Politzer). In case of profuse secretion, Politzer recommends vapours of turpentine. Eight to ten drops of some medicament in liquid form (two- to four-per-cent carbonate of soda, one-fifth- to one-half-per-cent of zinc sulphate, etc.) may be dropped into the catheter by means of a pipette, and then driven by the air douche into the Eustachian tube and the tympanic cavity.

If the exudate is abundant, paracentesis of the tympanic membrane is indicated (see page 474).

Diseases of the nose and pharynx are always to be treated in accordance with rules generally applicable to them (see Diseases of the Nose and Pharynx).

Any constitutional disturbances that may be present should be combated by means of nourishing food, life in climatic health resorts, etc., while syphilis, anæmia, heart and lung diseases, etc., should be treated in the usual way.

Patients with chronic serous inflammation of the tympanic cavity should not take cold river or sea baths. They must especially avoid diving and cold head douches.

A special form of chronic inflammation of the tympanic cavity is the so-called sclerosis of the mucous membrane (Tröltsch). Anatomically, one finds in sclerosis of this mucous membrane that the latter becomes more rigid and less elastic, and that the articulations between the auditory ossicles become, in consequence of this, less movable. The rigidity or complete synostosis or anchylosis between the stapes and fenestra ovalis is especially important, as the conduction of sound may thus be interfered with or wholly suspended. The tympanic membrane is thickened and lustreless, or in other cases atrophic and strikingly transparent. It is characteristic of this indurative inflammation that after the air douche, which occasions a loud, sharp, blowing sound, subjective relief follows, but no improvement in hearing.

In order to detect the immobility of the malleus and stapes, the manubrium and stapes should be carefully examined with the probe (Schwartze). To reach the latter with a probe, the posterior half of the tympanic membrane must be excised. If the stapes is movable, the patient feels pain upon the slightest touch with the probe, and a loud ringing noise, while in case of anchylosis there is but slight tenderness and no sound at all heard by the patient.

The prognosis of sclerosis of the mucous membrane of the tympanic cavity is unfavourable. The most that can be accomplished is to keep the disease from growing worse, or to secure temporary improvement.

The treatment conforms, in general, to the rules applicable to chronic serous inflammation. The air douche, is, however, according to Schwartze and others, of but little use. Warm steam or slightly irritating remedies (one- to three-per-cent chloral hydrate, very dilute glycerin, two-per-cent iodide of potassium, etc.) are especially to be recommended. To overcome the tormenting tinnitus aurium, bromide of potassium, amyl nitrite, acetanilide, closing the auditory canal air-tight (Politzer), and, if necessary, hypodermic injections of morphine, are employed. Here also attention must be paid to constitutional diseases, especially syphilis.

Acute suppurative inflammation of the tympanic cavity (otitis media acuta purulenta) arises from the entrance of microbes at the time of an injury, with the water while bathing, in the course of an acute exanthema, typhoid, diphtheria, etc. Aside from pus cocci, other micro-organisms characteristic of the special primary disease have been found.

The anatomical changes in acute suppurative inflammation of the tympanic cavity are hyperæmia and swelling, with a collection of pus in the tympanic cavity. The tympanic membrane usually becomes perforated, and the pus or muco-purulent secretion escapes into the auditory canal. The inflammatory process often extends to the Eustachian tube and the mastoid process.

The symptoms of acute suppurative inflammation of the tympanic cavity are pain, which is sometimes very severe, tinnitus aurium, vertigo, and impairment of hearing. Facial paralysis is not infrequent. The mastoid process is very often tender on pressure.

In severe cases brain symptoms appear—e. g., vomiting, stupor, delirium, and convulsions—and, in consequence of extension of the inflammation to the cranial cavity, death may ensue.

Examination of the auditory canal and the tympanic membrane yields essentially the same results as in acute serous inflammation, except that the hyperæmia is still more marked.

Perforation of the tympanic membrane usually follows in from two to five days after the beginning of the pain, sometimes later. In severe cases very large defects in the tympanic membrane may result. The duration of the disease is extremely variable. Its course is often very protracted, especially if the mastoid process becomes involved and proliferations of granulation tissue form in the tympanic cavity and the auditory canal. In exceptional cases gangrene has been known to complicate acute otitis media in badly nourished children, resulting in destruction of the tympanic membrane, external auditory canal, and auricle, as in noma.

The prognosis is not unfavourable if treatment is prompt and suitable. Complete recovery takes place, according to Schwartze, in about seventy per cent of the cases without permanent impairment of the hearing. The earlier the pus is evacuated from the tympanic cavity the better. The general condition of the patient is also of importance. In rare cases (two per cent, according to Schwartze) death results from meningitis. Death sometimes occurs very suddenly and early in the disease, before perforation of the tympanic membrane has taken place.

The treatment of acute suppurative otitis media is at the beginning antiphlogistic (leeches behind and in front of the ear, cathartics, confinement in bed, etc.). If there has been no spontaneous discharge of pus through the tympanic membrane on the third day, paracentesis of the membrane is performed in the posterior lower quadrant, or where the membrane bulges outward. The incision in the membrane must not be too small (see page 474). After paracentesis the pus is removed from the tympanic cavity by means of an air douche through the catheter or by Politzer's method. The auditory canal must be cleansed several times a day by syringing it out with three-per-cent boric acid, one-third-per-cent salicylic acid, one-per-cent thymol, four-per-cent resorcin, or weak solutions of permanganate of potash. After carefully drying the auditory canal with aseptic cotton it is plugged with iodoform gauze. After cessation of the pain, astringents are employed (see page 470, Chronic Suppurative Inflammation), or the insufflation of boric acid or iodoform, but in small quantities only, for fear of retention of pus.

In case of secondary involvement of the mastoid process there must not be too much delay in opening the mastoid antrum by trephining the mastoid process (see page 479).

Chronic suppurative otitis media either follows the acute form or begins as such.

The anatomical changes in chronic suppurative inflammation of the tympanic cavity may be mostly inferred from what has been said above in connection with acute suppuration. There is, as a rule, more or less loss of substance in the tympanic membrane. In the tympanic cavity pus is present in greater or less quantities, and there are proliferations of granulation tissue and connective-tissue adhesions between the tympanic membrane, the auditory ossicles, and the walls of the tympanic cavity. Ulcerations of the mucous membrane are more rare, occurring most frequently in tuberculosis, in the course of which the caseous destruction involves the bone (tubercular caries).

The principal symptom of chronic suppuration of the tympanic cavity is otorrhœa—that is, discharge of pus from the ear in very variable amounts. The difficulty in hearing is equally variable. Pain occurs particularly from subacute exacerbations, retention of pus, or ulcerative destruction.

The condition revealed by examination of the ear is to be inferred from the above-mentioned anatomical changes. It is much the same in acute exacerbations as in the acute process.

Among the sequelæ of chronic suppuration of the tympanic cavity which have a special influence upon the hearing, the following are especially important: Destruction of the tympanic membrane; changes in the tympanic cavity and in the bone, especially in the mastoid process; and, finally, secondary disease of the labyrinth.

The tympanic membrane has a marked regenerative power. Defects covering more than two thirds of its extent may become filled in, sometimes even after they have existed for years. Very frequently, however, defects in the tympanic membrane are permanent.

The prognosis of chronic suppuration of the tympanic cavity must be given with caution.

Every case of chronic otorrhœa is to be regarded as a disease that endangers life. It often ends fatally and very suddenly from meningitis, abscess of the brain, or sinus thrombosis with pyæmia. Its course is often very wearisome. It is difficult to determine in advance to what extent treatment may be successful in securing recovery or improvement of hearing.

The treatment of chronic purulent otitis media consists especially in carefully removing and disinfecting the pus by irrigating the auditory canal, or by employing the air douche through the Eustachian tube and injecting lukewarm antiseptic solutions through the catheter. For this purpose lukewarm three-per-cent boric acid, one-third-of-one-per-cent salicylic acid, one-per-cent carbolic acid, four-per-cent resorcin, and weak solutions of permanganate of potash are employed. When irrigating the tympanic cavity from the Eustachian tube and when using injections into the auditory canal, too much pressure must not be applied. Finally, the ear is to be carefully dried with aseptic cotton, and the auditory canal occluded with the same. This treatment is often sufficient, but more frequently it is necessary to apply astringents for from five to fifteen minutes after the removal of the pus (especially

zinc sulphate, one fifth to one per cent; lead acetate, one quarter to two per cent; sulphate of copper, one tenth to one half per cent; nitrate of silver, one to ten or thirty, the latter particularly in case of hyperæmia and swelling of the mucous membrane). If nitrate of silver is used, after it has been allowed to escape by inclining the head to one side it must be neutralized at once by injecting lukewarm concentrated salt solution, and, finally, lukewarm water should be injected in order to remove in this way the chloride of silver and the superfluous salt which otherwise cause irritation. In place of astringents in solution, dry powders may be insufflated, especially iodoform, boric acid, alum, etc., but not in too large quantities, for fear of causing retention of pus. In case of sub-acute exacerbations, neither astringents nor caustics are applied. It is very important that the general condition of the patient and any constitutional disease that may exist receive due consideration in treating suppurative inflammation of the tympanic cavity.

The treatment of complications is extremely important. Proliferations of granulation tissue are removed by cauterizing them with the nitrate-of-silver stick, with crystalline chromic acid, or the galvano-cautery. In case the mastoid process is involved, trephining is indicated. If there is swelling of the upper wall of the auditory canal in consequence of spreading of the inflammation, a free incision is to be made.

To bring about healing of defects in the tympanic membrane cauterization with nitrate of silver is resorted to, or the edges of the defect are cautiously freshened with the galvano-cautery.

The introduction of an artificial tympanic membrane should be tried, especially when there is deafness in both ears. This must only be done, of course, after suppuration has entirely ceased. These artificial membranes are prepared from the greatest variety of materials—from India rubber, for example, or from Lister's protective. Simple balls of cotton are often preferred by patients. Schwartze thinks that a thin, inflatable India-rubber tube with a globular end would perhaps be serviceable as a substitute for the tympanic membrane. The artificial membrane is, of course, to be removed at night.

Every one who suffers from defects in the tympanic membrane must protect himself against taking cold and against the entrance of dust into the ear by means of cotton plugs. Cold baths, and especially sea baths and cold head douches, are to be strictly avoided.

Croupous and diphtheritic inflammation of the tympanic cavity occurs sometimes in connection with simultaneous croupous and diphtheritic disease of the nose, the throat, and the lungs.

Diphtheritic inflammation may lead very quickly to extensive destruction of the tympanic cavity, especially in case of diphtheria com-

plicating scarlet fever. Complete deafness of the involved ear not infrequently ensues, and, in case both sides are affected in young children, deaf-mutism.

The treatment of diphtheritic inflammation of the tympanic cavity consists in immediate paracentesis (see pages 474, 475), irrigating the tympanic cavity with antiseptic solutions, and loosening the diphtheritic membrane by bathing the interior of the ear with limewater.

New growths of the tympanic cavity are most frequently polyps, which, like nasal polyps, usually originate in the tubular glands of the mucous membrane (so-called mucous polyps). They less frequently develop on the tympanic membrane, in the auditory canal, in the Eustachian tube, or in the mastoid antrum. Polyps are found most frequently in connection with chronic suppurative otitis media, and in the great majority of cases there is perforation of the tympanic membrane. Fibromatous polyps which originate, for example, in the periosteum are more rare. Polypous granulations, or granulomata, are to be distinguished, from the point of view of their origin and anatomical structure, from the true polyps found especially in connection with granulating, suppurative inflammations of the middle ear, but this distinction is without significance from a therapeutic standpoint, as the treatment is in all cases the same.

The treatment of polyps of the tympanic cavity consists in their earliest possible removal, as they may prove very dangerous, particularly from retention of pus in the middle ear. Their removal is most successfully accomplished by the use of Wilde's well-known wire snare without anæsthesia. On the following day the pedicle of the polyp is cauterized with nitrate of silver or, cautiously, with crystalline chromic acid. It is possible also in one sitting, with the aid of an anæsthetic, to remove the polyp by means of Wilde's snare and then to treat the pedicle at once with a very fine galvano-cautery point. In case of very hard polyps a galvano-cautery loop is used. Polypous granulations of the auditory canal found in connection with caries are removed with a sharp spoon by the aid of a speculum. The employment of the sharp spoon in the tympanic cavity is to be avoided as far as possible.

Under the name cholesteatoma of the temporal bone various pathological conditions are included. In the rarest cases we have to do with a tumour originating in the bone or in the soft parts—the so-called pearl tumour (Virchow). This pearl tumour or cholesteatoma appears usually on the temporal bone, in the soft membranes of the brain and in the interior of the brain, and consists of white pearls with a silklike lustre—that is, of scales of epithelium analogous to the horny epithelium of the outer skin. Most authors—e. g., Chiari, Eppinger, Eberth, and others—assume that the cells of the cholesteatoma really come from endothelial cells, while Ziegler, on the contrary, holds that they are derived from epithelial cells and that they may be cells of the primitive medullary canal—i. e., the outer germinal layer that have strayed during the development of the brain. The fact that small hairs are found in cholesteatomata favours, according to Ziegler, the theory that they are epithelial in character. According to Fr. Bezold and Politzer, the cholesteatoma is the result of a proliferation of epithelium with transformation of the cells

into epidermis cells. Kuhn believes that cholesteatomata of the ear are principally of congenital origin. They are to be regarded in part as genuine dermoid cysts.

The cholesteatoma of the temporal bone is probably at times not a genuine tumour, but is caused by retention of more or less dried products of inflammation in the tympanic cavity, in the mastoid antrum, in the external auditory canal, etc. (Tröltsch). Fatty, cheesy (tubercular) pus sometimes forms the nucleus of such cholesteatomata, and about this has gathered an aggregation of cholesterine crystals and cells arranged in layers like those of an onion and similar to epidermis cells. According to Wendt, the cholesteatoma of the temporal bone is caused by desquamative inflammation of the mucous membrane of the middle ear.

The removal of these cholesteatomata is an urgent necessity, as they occasion serious destruction and may become dangerous to life—e. g., by causing meningitis, sinus thrombosis, and abscess of the brain. Their treatment consists in softening the masses of cells and cholesterine by means of alkaline solutions applied through the auditory canal and the Eustachian tube.

In marked cases in which the cholesteatoma has reached a large size the latter is removed by chiselling open the cavity formed by the tumour after dividing the skin one centimetre behind the ear down to the apex of the mastoid process and displacing the periosteum to one side. Schwartze, Stacke, and others have recommended and successfully executed the radical operation for cholesteatoma by the formation of permanent wide openings both toward the external auditory meatus and the region behind the ear. Siebenmann and others recommend covering the bony cavity with skin-grafts in order to insure a permanent cure.

Malignant tumours (sarcomata and carcinomata) are very seldom primary, but the middle ear is more frequently involved secondarily from the breaking through of tumours in neighbouring parts—e. g., tumours of the base of the skull, the parotid, and the antrum of Highmore.

Successful treatment of malignant tumours of the middle ear by extirpation is scarcely possible, so that they can only be treated symptomatically.

Nervous diseases of the middle ear are of slight surgical importance. I mention especially neuralgia of the tympanic plexus formed by branches of the fifth and ninth cranial nerves. The most frequent cause of this otalgia is probably a decayed molar, then syphilis, anæmia, hysteria, difficult eruption of a wisdom tooth, diseases of the naso-pharyngeal space, etc. The pain, which is almost always on one side, begins in the ear and radiates out into other branches of the fifth nerve.

The treatment of otalgia is directed chiefly against its cause, which is to be determined as accurately as possible. In applying electricity, the anode of the constant current is placed in the auditory canal and the cathode upon the sympathetic. In case of neuralgia of the auriculo-temporal nerve, neurectomy is to be recommended between the tragus and the condyloid process of the lower jaw (see also § 34, pages 239–243, Pathology and Treatment of Neuralgia of the Face).

Schwartze mentions also clonic contractions or spasm of the tensor-tympani muscle, the tympanic membrane being drawn inward, and a loud cracking sound being audible at the same time. As a result of what are probably

similar spasms of the stapedius muscle, hammering and buzzing in the ear occur which are said to be perceptible to another person (Schwartze).

The treatment of these spasms consists in the use of nerve tonics, antispasmodics, and the galvanic current. In case of spasm of the tensor tympani with tormenting sounds in the ear, tenotomy of this muscle may be indicated.

Tenotomy of the tensor-tympani muscle is performed by most aural surgeons behind the manubrium, less often in front of it. A small curved tenotome is inserted behind the manubrium and the tendon is divided on the latter. With reference to the indications for this operation and its details, as well as those of the rarely performed tenotomy of the stapedius muscle, the reader is referred to treatises on diseases of the ear, as they are only performed by specially train~d aural surgeons.

Paracentesis of the Tympanic Membrane.—We have already, in connection with diseases of the tympanic membrane and the tympanic cavity, repeatedly mentioned incision or puncture of the tympanic membrane, so-called paracentesis of the same. We can here speak only very briefly and in a general way of the indications and details of this operation, which is usually performed only by aurists. For a fuller description, the reader is referred to treatises on diseases of the ear, especially those of Tröltsch, Schwartze, Politzer, Hartmann, and Urbantschitsch.

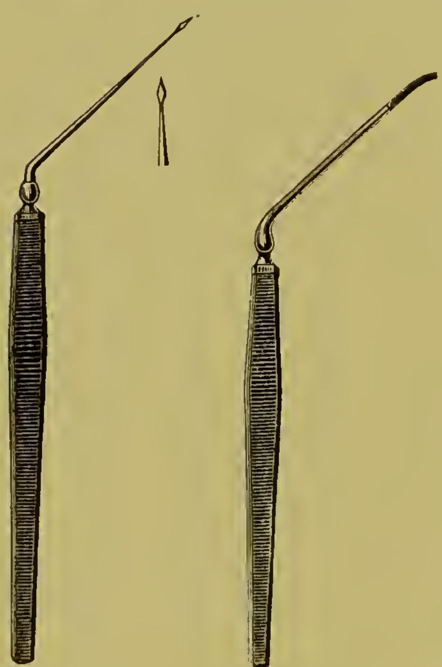

a *b*

Fig. 270.—Myringotomes: (*a*) puncture needle; (*b*) knife for dilation of the incision (Schwartze).

Paracentesis of the tympanic membrane is indicated in case of much exudation in the tympanic cavity during acute and chronic serous and suppurative inflammations, anomalies of tension and acute inflammation of the tympanic membrane, tinnitus aurium that yields to no treatment, and closure of the Eustachian tube. It is also performed to allow the removal of polyps of the tympanic cavity, to break up adhesions, and, finally, for diagnostic purposes.

The operation should be repeatedly practised on the cadaver or on anatomical preparations. As instruments, various forms of spear-pointed needles are used—e. g., Schwartze's well-known bent myringotome (see Fig. 270).

The operation is performed with antiseptic precautions. After careful disinfection of the myringotome in absolute alcohol and drying the same with sterilized gauze, the tympanic membrane is divided, with the aid of the best possible illumination, usually in the posterior lower quadrant. The incision must not be too small, not less than two millimetres in length. It must also be so directed that the radiating fibrous layer of the tympanic membrane is divided transversely (see Fig. 271). If the membrane bulges at one point, it

is opened here. The pain attending paracentesis is severe, but usually of short duration. After the cavity has been opened, the exudate is evacuated into the auditory canal by means of the air douche or by irrigation through the Eustachian tube with a three-quarters-of-one-per-cent solution of common salt by means of the catheter. The accidents that may attend the operation are vertigo, fainting, vomiting, and, above all, associated injuries caused by an unskilled operator, or subsequent inflammation in case the operation is not performed aseptically. The hæmorrhage is usually insignificant. The after-treatment consists in drying the auditory canal and plugging it with aseptic iodoform gauze and applying cotton and a bandage. The patient must keep in his room and abstain from smoking. The incision in the tympanic membrane has to be kept open sometimes for a longer or shorter time, according to the character of the case. This is done mainly by means of the air douche and irrigation through the Eustachian tube, or, if necessary, by cautious cauterization or the introduction of a probe. A permanent perforation of the tympanic membrane after paracentesis is of rare occurrence.

Fig. 271.—Location and length of the incision in performing paracentesis of the membrana tympani (Schwartze).

For the operative treatment of adhesions of the tympanic membrane with the labyrinth wall or the floor of the tympanic cavity, and for a description of partial and complete excision of the tympanic membrane and the ossicles, see the treatises on the ear, especially that of Schwartze, Lieferung 32 der Deutschen Chirurgie.

§ 77. **Malformations, Injuries, and Diseases of the Eustachian Tube.**—Among disturbances of development of the Eustachian tube, the very rare cases of its absence, combined with other malformation of the organ of hearing, should be mentioned (Gruber). Congenital atresia and absence of the pharyngeal opening of the tube are just as rare. Stenosis is more frequent, as well as angular flexion and unsymmetrical position of the two pharyngeal openings, conditions which are important in connection with catheterization of the tube. In case of ossification gaps in the carotid canal, injury to the internal carotid by forcible probing of the tube with pointed, inflexible probes, is possible.

Injuries of the Eustachian tube are rare, owing to its protected position. They occur most frequently in consequence of the unskilful introduction of Eustachian catheters or bougies, operations in the naso-pharyngeal space, resection of the superior maxilla, and gunshot wounds.

Still less frequently are foreign bodies found in the Eustachian tube. Fragments of bougies, needles, bits of vomited food, and even nematoids, have been found.

Inflammation of the tube alone (salpingitis) seldom occurs. It is usually secondary to inflammation of the naso-pharynx or the tympanic cavity. In this way acute and chronic serous inflammations of the tube result, with hyperæmia, swelling, and increased secretion in the same, especially near its

pharyngeal opening, as is shown by rhinoscopic and pharyngoscopic examination. Croupous and diphtheritic inflammation spreads in the same way from the pharynx and the nose to the tube. In consequence of all these inflammations, ulceration, stenosis, and atresia of the tube arise. They also occur with syphilitic and tubercular processes, and in connection with variola and diphtheria.

The treatment of catarrh of the tube consists in the use of disinfecting and astringent gargles, irrigation with salt water, use of the nasal douche or naso-pharyngeal syringe, and cauterization and scarification in the region of the pharyngeal opening with the aid of rhinoscopic or pharyngoscopic illumination. To check the hypersecretion in the tube, use is made of the air douche, and a few drops of an astringent fluid are insufflated through the Eustachian catheter. In case of ulceration, cauterization with nitrate of silver or the galvano-cautery, under illumination with the mirror, is serviceable. If there are syphilitic ulcers, an antisyphilitic treatment by inunction or the administration of iodide of potassium is usually sufficient. Stenoses of the tube are treated by use of the air douche or careful introduction of laminaria bougies, which were first recommended by Schwartze. Cicatricial deformities near the pharyngeal opening or within the tube are usually incurable.

Among neuroses of the tube mention should be made of clonic spasm of the muscles of the tube and palate, both in case of sound and diseased ears, which may be unilateral or bilateral. It is characterized by a crackling sound in the ear, which is sometimes very loud and distressing. The cause of this spasm is unknown. Where there are inflammatory conditions, it may be explained as a reflex spasm. Treatment consists in the use of electricity.

Paralysis of the muscles of the tube occurs most frequently in consequence of diphtheria. It generally disappears spontaneously.

New growths in the tube are rare. Polypous proliferations at the pharyngeal opening of the tube are the most common form. Exostoses have been observed in rare cases.

§ 78. **Injuries and Diseases of the Mastoid Process.**—The mastoid process is made up of larger or smaller cavities containing air (mastoid cells), and is a continuation of the tympanic cavity, with which it communicates through an opening near its upper wall. In this way is to be explained why the discharge of pus from the mastoid antrum is made difficult, and why retention of pus has so often to be overcome by trephining the mastoid process.

Injuries of the mastoid process usually arise from direct violence, such as a kick or a blow. Hæmorrhage takes place within or around the antrum with or without fissures, depending on the amount of violence. In case of fractures through the entire thickness of the cortical substance, a subcutaneous emphysema ensues, which is usually circumscribed and which may gradually assume larger dimensions. The mastoid process sometimes breaks off at its base, and necrosis of the same

may result. In case of fracture of the mastoid process from great violence, there are, as a rule, fractures of the temporal bone—e. g., through the aquæductus Fallopii with facial paralysis, and through the base of the skull.

The treatment of fractures of the mastoid process conforms to the rules given for fractures of the skull (see §§ 8 and 9).

Inflammations of the mastoid process are mostly secondary to those of the tympanic cavity, and they are therefore either acute and chronic serous or acute and chronic suppurative inflammations, with the formation of an acute or chronic abscess in the mastoid cells (empyema). Chronic inflammation and suppuration, combined with caries and necrosis of the mastoid cells, are usually of tubercular origin. Primary acute periostitis and ostitis (osteomyelitis) of the mastoid process also occur, but less frequently (Hessler).

There are, as a rule, no characteristic symptoms in connection with acute and chronic serous inflammation of the mastoid antrum, such as are present in acute and chronic suppurative inflammation.

Fever is always present in acute suppurative inflammation of the mastoid cells, the mastoid process is very painful and tender on pressure, the overlying skin is reddened and swollen, and the posterior upper wall of the auditory canal often bulges outward. If the bone is already perforated by pus, a fluctuating subperiosteal abscess is demonstrable, or the latter is the result of secondary suppurative periostitis.

In chronic suppuration of the mastoid process characteristic symptoms may be more or less completely absent. If a distinct fœtid odour exists in spite of the most careful cleansing of the ear, one must consider the possibility of the existence of such a chronic suppuration in the mastoid antrum. The frequent induration and sclerosis of the mastoid process is very noticeable. The diagnosis is simplest in those cases where fistulæ already exist, and the probe touches carious or necrotic bone. As a result of empyema of the mastoid antrum, which runs a very chronic course with pronounced thickening and sclerosis of the bone, death not infrequently ensues unexpectedly from meningitis, sinus thrombosis, or abscess of the brain. This is because the thickened bony covering presents an insuperable obstacle to the spontaneous discharge of the pus.

Percussion has also been made use of for the detection of pus in the mastoid antrum. The percussion note is dull, especially in the case of abscesses that are superficially situated, while in those more deeply situated dulness can not be made out. The diagnostic importance of this method of investigation seems to me still questionable. Gabritschewski and Okunjew found in a case of mastoid abscess a diminution in the conduction of sound when

the vibrating tuning fork was placed on the parietal bone, and at the same time the mastoid process was auscultated.

Körner and Wild hold that dulness of the percussion note is present only in disease of the bone—i. e., centrally situated foci of suppuration—and not as the result of occlusion or diminution in the size of the air spaces within the mastoid process due to collections of pus.

Typical caries and necrosis of the mastoid process, with the formation of fistulæ running through the cortical substance and the posterior wall of the auditory canal, are caused chiefly by tuberculosis. It is a common disease in childhood. The location and extent of this tuberculosis of the bone is very variable. It generally takes the form of an ulcerating caries. Extensive necrosis is less common.

Very acute and extensive necrosis of the mastoid process and the temporal bone occurs especially in connection with typhoid and scarlet fever. Wreden once observed complete necrosis of the temporal bone in a child of eight months after scarlet fever. The child lived ten hours after the expulsion of the sequestrum. Caries of the mastoid also occurs in diabetes.

As is true of every chronic suppurative process in the mastoid process, so is also caries or necrosis of the temporal bone a very treacherous disease, leading often to sudden death from acute meningitis, sinus thrombosis, or abscess of the brain.

Gravitation abscesses not infrequently form in the course of chronic suppuration in the mastoid process and temporal bone, which may extend downward along the neck and follow the connective-tissue clefts as far as the sternum, under the scapula, or into the axillæ (König, Schwartze).

Primary inflammation of the periosteum of the mastoid process is not very common, and is usually secondary to inflammation of the mastoid cells. Suppurative periostitis may give rise to necrosis of the bone and to the above-mentioned gravitation abscesses.

The treatment of acute inflammation of the mastoid cells, which gives rise to pain and tenderness on pressure, consists at first in the application of ice and leeches. As soon as more marked swelling of the overlying soft parts develops, with tenderness on pressure, an incision is made down to the bone about one centimetre behind the insertion of the auricle and parallel to it. One must, of course, not wait for fluctuation. If there is pus in the mastoid cells, trephining the mastoid antrum is indicated, in order to allow the pus to escape externally (see below).

If, in the course of suppurative inflammation of the middle ear, the mastoid process becomes tender on pressure, the pus must be evacuated

as soon as possible from the tympanic cavity by paracentesis of the tympanic membrane (see pages 474, 475), or by enlarging an already existing perforation that is too narrow.

If caries and necrosis of the mastoid process or the temporal bone are present, energetic scraping with a sharp spoon is undertaken after making an incision, elevating the periosteum, and enlarging the fistulous tracts with a chisel or simply with a spoon.

In case of gravitation abscesses, a careful examination must be made and the connective-tissue clefts followed, in order to divide all fistulous tracts and to drain, if necessary, the abscess cavity.

Acute inflammation of the periosteum of the mastoid process is treated at first by antiphlogistic measures (ice, leeches), and before suppuration begins an incision should be made down to the bone one centimetre behind the insertion of the auricle from above downward and parallel with the latter.

Trephining the Mastoid Process.—Trephining the mastoid process—that is, making an artificial opening into the mastoid antrum—is an extremely serviceable operation, which, as I can verify from my own experience, has rendered complete recovery possible in very desperate cases. We are under obligation to Schwartze especially for the development of this operation.

Trephining the mastoid process is indicated in the following cases:

1. When there is acute inflammation of the mastoid process with retention of pus in the mastoid antrum.

2. In chronic inflammation of the mastoid process with repeated swelling of the same which only partially subsides, and in case of chronic suppuration, with or without the formation of fistulæ and gravitation abscesses, even when no threatening symptoms exist.

3. In case of an externally sound mastoid process with retention of pus or the formation of cholesteatomata in the middle ear which can be removed in no other way, as soon as symptoms of a dangerous complication appear.

4. In severe neuralgia in the mastoid process when all other treatment has been fruitless, though the mastoid process be outwardly sound and there is no retention of pus in the middle ear.

5. As a preliminary operation in case of virulent suppuration of the middle ear with a marked fœtid odour, for the purpose of irrigating the middle ear from behind.

The operation is always performed with antiseptic precautions after shaving the hair and carefully disinfecting the skin.

For the sake of avoiding the posterior auricular artery, the incision in the skin is made about one centimetre behind the insertion of the auri-

cle, from above downward, and from two and a half to five centimetres in length, according to the size of the process. After dividing and pushing back the periosteum, the bone is chiselled with hammer and gouge. The bone may be difficult to chisel, especially in case of thickening and sclerosis of the cortical layer. If there are fistulæ or carious places, entrance to the mastoid antrum is gained from these very easily. The linea temporalis is the upper boundary, which must not be transgressed in cutting the bone. This runs on a level with the upper wall of the auditory canal from in front backward, and divides the mastoid portion from the squamous portion of the temporal bone. The bone must be chiselled cautiously in this region, as otherwise the middle cranial fossa may easily be opened. The chisel should always be held so that it points forward and downward, and not backward away from the ear. The ridge of bone above the auditory meatus on the posterior and upper surface of the osseous auditory canal, which can usually be distinctly felt, is also an important landmark. It lies somewhat higher than the floor of the mastoid antrum. The mastoid process is bounded in front by the posterior border of the osseous auditory canal, and its posterior and lower boundary is easily felt.

Stacke, Robertson, and others recommend, for the purpose of opening the so-called cupola space, removal of the posterior wall of the bony auditory canal. After separation of the cutaneous covering of the auditory canal, a bent probe is passed as a guide along the posterior wall of the canal and through the apertura antri into the antrum itself.

It is often necessary to chisel open long, fistulous tracts in the bone, until finally one comes upon the sequestrum or focus of the disease.

After carious and necrotic portions of bone have been chiselled away or scraped out, the antrum is irrigated with boric acid. If the irrigation fluid does not flow off in the direction of the auditory canal or the pharynx, this is not proof that there is no communication between the antrum and the middle ear. There is usually full recovery of this communication within a few days. Lastly, the cavity in the bone is packed with iodoform gauze and covered with an antiseptic dressing. I far prefer this packing with iodoform gauze to the use of a drainage-tube. Should the dura or the lateral sinus be exposed uninjured, it is of no consequence, if the operation is aseptic and the wound runs a normal course. Injuries to the lateral sinus and the aquæductus Fallopii can easily be avoided. In case of injury to the former, the hæmorrhage is stopped by aseptic packing.

The after-treatment is very important. Above all, the wound must not be allowed to heal too quickly. Aurists are in the habit of inserting a conical lead nail if the wound is to be kept open for some time.

It is often difficult to determine when this lead nail may be removed, but it should always remain until suppuration inside the ear has become very slight. Packing the wound with iodoform gauze is more advisable than inserting such a lead nail. Irrigation of the wound should be avoided as far as possible. I usually irrigate it through the auditory canal only in case of foul-smelling pus; I follow, in short, the principles of treatment that have been given by Krönlein, for instance, and other surgeons.

In case of wide communication between the mastoid process and the auditory canal or the middle ear, open bone cavities lined with epithelium sometimes persist after trephining, in consequence of the union of the epithelium of the inner ear with the outer skin. These readily become the cause of processes of decomposition and suppuration (E. Hoffmann). They are easily prevented by avoiding during the operation too wide a communication between the auditory canal or the middle ear and the mastoid antrum, and by subsequent cauterization.

Among new growths in the mastoid process we have already (page 472) mentioned the cholesteatoma. The most common of the other tumours are fibrous polyps of the mucous membrane of the mastoid cells, sarcoma, and carcinoma. We have already (page 29) mentioned the occurrence of dermoid cysts in the mastoid region, and other congenital cysts—e. g., oil cysts. Osteomata appear occasionally on the outer surface of the mastoid process. Lastly, gummata of the mastoid process have been repeatedly observed.

In rare cases, neuralgia of the mastoid process occurs without anatomical changes. If the pain in the bone becomes unbearable and nerve remedies are without effect, trephining has repeatedly been performed, or a part of the bone chiselled away. It is true that an old pus focus is sometimes found to be the cause of the supposed neuralgia of the bone.

§ 79. **Malformations, Injuries, and Diseases of the Internal Ear or Labyrinth.**—Injuries and diseases of the labyrinth are of small importance for the surgeon. They are treated exclusively by ear specialists. We can only occupy ourselves here with a very brief mention of its injuries and diseases, and must refer the reader, for a more thorough treatment of the subject, to the text-books on the ear.

In case of malformations of the labyrinth there is usually absolute deafness. Incomplete development and entire absence of the labyrinth, with corresponding malformations of the external ear, have been observed.

Injuries of the labyrinth occur especially from the entrance of foreign bodies, from rough extraction of foreign bodies in the tympanic cavity, from gunshot injuries, and from the action of concentrated mineral acids or of hot or boiling fluids. Schwartze mentions the case of an English woman who killed six husbands by pouring melted lead into the ear during sleep.

Indirect injuries are more frequent than the direct. The former are most commonly caused by concussion of the organ of hearing, from a blow, a loud

sound, from injuries to the head, and especially from fractures of the base of the skull. Direct and indirect injury to the labyrinth gives rise to a larger or smaller effusion of blood, with or without injury to the nerve apparatus, or the latter may be affected in consequence of subsequent inflammation or atrophy.

The symptoms of injury to the labyrinth are complete or partial deafness; the latter may show itself in the lack of perception of certain successions of tones. The partial or complete deafness is temporary or permanent according to the degree of the injury. Vertigo is also a frequent symptom, as is painful sensitiveness to sound, and, finally, loud tinnitus aurium (ringing and humming) is often heard. It frequently happens, of course, that the brain symptoms resulting from concussion or injury to the brain are so predominant that injury to the labyrinth can only be made out after the disappearance of the special brain symptoms. When death results, it is due principally to complicating injuries to the brain or secondary suppurative meningitis.

With regard to inflammations and disturbances of circulation, the reader must be referred to text-books on the ear. It need only be mentioned regarding disturbances of circulation that the disagreeable subjective auditory sensations which are so frequent are caused by disturbances of circulation in the labyrinth, and upon hyperæmia as well as anæmia.

Deafness which ensues after injuries to the head especially interests the surgeon. As we have seen in connection with the study of fractures of the base of the skull (§ 9), fractures of the petrous portion of the temporal bone are comparatively frequent. Schwartze observed twelve cases of deafness on one side and three on both sides after probable fracture of the base of the skull. Deafness after injuries to the head can be caused by contusion and laceration of the auditory nerve or by compression of the nerve by an effusion of blood in the internal auditory meatus; furthermore by an effusion of blood in the labyrinth with rupture of the membranous labyrinth, or by injury to the auditory centres in the brain. These centres may be affected by very trivial injuries to the head. Schwartze and Gräfe observed deafness from injury to the auditory centre in the brain in the case of a boy of seven years whose ears were boxed on the street by an older schoolmate, who also inflicted several blows upon the boy's head with his hand.

Deafness which does not appear until several days or weeks after the injury may be the result of accidental complications, and not of the injury as such. Long-continued application of ice to the head in such a way that cold water runs without hindrance into the ear, causing inflammation of the middle ear, is sometimes, according to Schwartze, the cause of this late deafness following injuries to the head.

§ 80. **The Causes of Death in Diseases of the Ear.**—We have no reliable data with regard to the frequency with which death ensues in diseases of the ear, particularly in suppuration. We only know that too often neglected suppuration of the ear results fatally, frequently to the great surprise of the laity. A collection of statistics by Schwartze proves that fatal diseases of the ear occur not uncommonly in the German army. There are about three cases each year. Schwartze has tabulated twenty-eight fatal cases (two of meningitis, ten of abscess of

the brain, and sixteen of thrombosis of the cerebral sinuses with subsequent pyæmia). We may infer from these statements that diseases of the ear have in general a rather frequent fatal termination.

Death occurs most frequently in suppurative otitis media from secondary involvement of the brain and its membranes and of the sinuses of the dura (meningitis, abscess of the brain, sinus thrombosis with pyæmia). The most frequent cause of death in chronic suppuration of the middle ear is probably phlebitis of a dural sinus—that is, sinus thrombosis with subsequent pyæmia from purulent softening of the thrombus. General miliary tuberculosis not infrequently follows tubercular suppuration of the ear. Death from malignant tumours of the ear, or from the erosion of vessels involved in a suppurative process, is comparatively rare.

Wendt, Zaufal, and others have shown that even in mild catarrhal inflammations, with mucous or serous effusion in the tympanic cavity and without perforation of the tympanic membrane, death may result from suppurative meningitis and thrombosis, especially of the lateral sinus. The suppurative meningitis following diseases of the ear is found chiefly at the base of the brain, less often on the convexity. It usually arises from an extension of the inflammation from the tympanic cavity through the vault of the tympanum, or from the mastoid antrum through the canalis petroso-mastoideus (Voltolini), or, finally, from the labyrinth through the internal auditory meatus.

Abscesses of the brain are most commonly situated in the temporal lobe or in the cerebellum. About one half of all abscesses of the brain, according to Schwartze, result from diseases of the ear. Disease of the right ear leads more frequently to brain abscess, because the groove for the lateral sinus on the right side reaches farther forward and outward on to the pyramid. In other words, the bony partition between the middle ear and the cranium is thinner on the right than on the left side (Körner).

Fatal hæmorrhages from erosion of the internal carotid, the middle meningeal, the sinus of the internal jugular, and the petrosal and lateral sinuses, are, as has been said, very rare.

In case of hæmorrhage from the internal carotid, the common carotid should always be ligated in continuity, in spite of the fact that the results have been thus far so unfavourable, since secondary hæmorrhage usually follows the establishment of the collateral circulation. Packing the auditory canal and continued digital compression are usually insufficient. For ligation of the middle meningeal artery, see § 15, page 112. Hæmorrhage from a sinus is arrested by packing and compression (see § 15, page 109).

CHAPTER IX.

INJURIES AND DISEASES OF THE SALIVARY GLANDS (PAROTID, SUBMAXILLARY, AND SUBLINGUAL).

Review of the anatomy of the salivary glands.—Injuries to the salivary glands.—Fistulæ of Steno's duct.—Inflammations (mumps, suppurative parotitis, angina Ludovici, and other inflammations).—Retention of secretion in the salivary glands.—Salivary cysts.—Salivary concretions.—Foreign bodies.—Tumours of the salivary glands, especially of the parotid and submaxillary.—Complete extirpation of the parotid and submaxillary.

§ 81. **Anatomy of the Salivary Glands.**—The salivary glands are racemose glands which discharge their secretion into the mouth.

The parotid gland extends from the region of the external auditory meatus downward to the angle of the lower jaw. It is separated from the latter by the external carotid and the venous trunk formed by the union of the temporal and internal maxillary veins. The external carotid sometimes passes through the substance of the gland. The facial nerve with its branches divides the gland, in an incomplete way, to be sure, into a thicker outer layer and a thinner inner layer. The excretory or Steno's duct begins at the boundary of the upper and middle thirds of the gland from its anterior border, crosses the masseter in a horizontal direction at about the level of the nares, then passes beneath the zygomatic muscles, pierces in an oblique direction the buccinator and the mucous membrane of the cheek, and opens into the oral cavity opposite the second upper molar.

The submaxillary gland fills the triangular space between the lower jaw and the two bellies of the digastric. It is covered by the skin, platysma, and a thick layer of connective tissue, the so-called supra-hyoid fascia. Across the posterior angle of the gland the facial artery and vein pass to the outer surface of the lower jaw. The excretory duct (Wharton's duct) begins in the upper half of the gland, traverses the mylo-hyoid muscle, crosses the lingual nerve at an acute angle, and passes in a median direction to the floor of the oral cavity, where it empties by the side of the frenum of the tongue.

The sublingual gland is situated upon the floor of the oral cavity, directly beneath the mucous membrane, between the genioglossus muscle and the inner surface of the lower jaw. It consists of several divisions, each of which has its special excretory duct. Several unite to form one larger excretory duct (Bartholin's duct), which either joins the Whartonian duct or empties independently close beside it. The remaining excretory ducts of the sublingual gland (the ducts of Rivini), five to eight in number, perforate the

mucous membrane of the floor of the mouth with very fine openings, sometimes in a row parallel to the teeth from near the orifice of the Whartonian duct to the neighbourhood of the last molar. In other cases their orifices are more scattered, lying between the tongue and the gum, close beside the root of the frenum of the tongue, to the inner side of the caruncula salivalis (Henle).

§ 82. **Injuries of the Salivary Glands** are, in general, of rare occurrence, especially those of the submaxillary and sublingual. Injuries of these two glands are without special significance. Injuries of the parotid are the most common and of the most practical importance. The latter are caused most commonly by rapier cuts in students' duels and by operations. These injuries usually run their course without occasioning disturbance, particularly if the wound heals by primary union. Subcutaneous collections of saliva occasionally appear later on in the form of cystic swellings, which disappear spontaneously or by the use of a bandage. Such collections of saliva rarely break through externally, giving rise to a fistula. The latter is more likely to form when the injury to the gland heals with suppuration, in which case small fistulæ, with more or less abundant secretion, may then persist. They heal spontaneously after weeks or months, or they may be very quickly closed by cauterization with the fine point of a thermo-cautery or galvano-cautery, which is more effective than nitrate of silver and other caustics.

Fistulæ of Steno's duct, after it has been injured in the region of the cheek, are often more difficult to heal if the central end of the duct has grown together with the outer skin forming a so-called labiform fistula, with escape of saliva externally. They usually develop after the wound situated on a level with the nares (sword-cut, puncture, wound from operations) has been sutured without knowledge of the existing injury to the duct. After the wound is healed by primary union saliva collects in the form of a fluctuating tumour beneath the skin, and this breaks through externally or internally into the oral cavity. In the latter case a sort of spontaneous cure follows, the salivary duct then opening permanently into the oral cavity at an abnormal place in the mucous membrane. In other cases the wound does not heal at all on account of the constant escape of the saliva. The opening is usually very small. Finally a labiform fistula results, in which the central end of the duct unites directly with the skin, the epithelium of the duct becoming continuous with the epidermis. Fistulæ of the salivary ducts occur, however, not only after injuries, but also after suppurative or gangrenous destruction of the tissue of the cheek, and after obstruction of the duct by foreign bodies or salivary concretions.

Many annoyances are caused by fistulæ of Steno's duct which open externally. Saliva constantly flows out in large amounts, especially during mastication. Eczema sometimes appears upon the surrounding skin. Digestion and the general health also suffer sometimes in consequence of the loss of saliva.

Treatment of Injuries to Steno's Duct.—When there is an injury to this part of the cheek on a level with the nares, a careful examination should be made to determine whether or not the salivary duct is injured. If the wound in the cheek is a penetrating one, only the outer skin should be closed by suture, so as to allow the saliva to flow into the mouth. If the wound is not a penetrating one, Genzmer recommends that, after completely arresting the hæmorrhage, the divided ends of the salivary duct be exposed, and then, by means of deep catgut sutures, brought into as close apposition as possible (the suture must not enter the lumen of the duct). In suitable cases the central end of the salivary duct may be brought through the mucous membrane into the mouth. The peripheral end of Steno's duct may be more easily found by passing a fine metallic or whalebone probe into its orifice opposite the second upper molar.

In case a collection of saliva in the form of a subcutaneous fluctuating tumour should appear after the wound has healed, compressive dressings should first be tried. I was able in this way to cure permanently an injury to Steno's duct which was received in a student's duel. One may also open the cicatrix, which is usually thin, by inserting a fine probe, allow the saliva to flow off externally, and then, if necessary, after cauterization of the little wound made by the probe, apply dressings that exert pressure for a few days. It is also a good plan to make an artificial opening through the mucous membrane from without inward.

If a fistula of Steno's duct is already present, and but a short time has elapsed since the injury, cauterization of the fistula should at first be tried with the small point of a thermo-cautery or galvano-cautery, and a dressing that exerts pressure applied. Excision of the fistula, with or without perforation of the mucous membrane, and careful suture of the wound, can also be tried.

In case of fistulæ lined by mucous membrane and skin (labiform fistulæ), the peripheral part of the canal is usually contracted or obliterated, which should be determined by passing a probe through the orifice in the mouth opposite the second upper molar. The simplest course in treating this kind of fistula is to excise the external portion by means of two elliptical incisions and change the external fistula into an internal one. This method is usually successful, and has been

strongly recommended by Dieffenbach, Deguise, Beclard, and others. It is done as follows: The fistula is at first excised by means of two elliptical incisions through half the thickness of the cheek. A fine trocar is then stuck through the bottom of the wound in two places about half a centimetre apart and a lead or silver wire or a piece of thread or catgut is drawn through the two holes. The ends of the wire are twisted together by a few turns, or the catgut or silk is tied in a knot from within the mouth and the threads are cut off short. The external wound is then closed by suture. After healing has taken place, the saliva flows through the wounds made by the trocar into the mouth. The wire or the thread either cuts through so that a canal is formed, or, better, these are removed after a time, so that both openings remain patent in consequence of the constant flow of saliva into the mouth.

Kaufmann healed a fistula of Steno's duct by inserting a thin India-rubber tube into the fistula in such a manner that one end of the small tube projected half a centimetre into the mouth, while the other end was cut off obliquely and so placed that the saliva could flow directly into it and allow the external opening of the fistula to remain dry.

The central end of the salivary duct has also been exposed and freed from its surroundings, an opening made in the mucous membrane of the cheek, and the end of the duct sutured into this opening.

The attempt has been made to dilate a constriction of the peripheral part of the duct by inserting strands of catgut.

In case of a salivary fistula in the masseteric portion of the duct—which, owing to obliteration of the peripheral portion, is not accessible to direct treatment by freshening and suturing the fistulous opening, and whose central end can not be brought through the mucous membrane of the cheek—Viborg has recommended bringing about atrophy of the parotid by tying off the duct.

§ 83. **Inflammations of the Salivary Glands.**—Inflammations of the salivary glands are mostly due to microbes which pass from the mouth through the excretory ducts of the glands and gain access to their parenchyma. They are often found in connection with putrefaction of the secretion of the mouth in stomatitis. In other cases inflammation of the salivary glands is caused by infection through the blood. To the latter class belongs, for example, the suppurative parotitis which occurs in metastatic pyæmia. Infectious inflammations after wounds of the salivary glands may be easily avoided by antiseptic treatment.

Parotitis.—Inflammation of the parotid, or parotitis, is most commonly observed in the course of severe acute infectious diseases—e. g.,

typhoid, variola, or diphtheria—and is usually the result of infection from a stomatitis with putrefaction and stagnation of the secretion of the mouth. Parotitis in the course of pyæmia is due, as has been said, to metastasis—that is, to microbes that have been brought to the gland by way of the circulation. Epidemic parotitis or mumps is an inflammatory swelling of the parotid, and often also of the submaxillary and sublingual glands, which occurs in the form of an epidemic and is contagious. This epidemic parotitis sometimes results from a stomatitis, in which microbes gain access to the parenchyma of the glands through the salivary ducts, and sometimes metastatically from infection through the respiratory or digestive organs. In the latter class of cases secondary catarrhal stomatitis often arises because pathogenic microbes gain access to the mouth with the saliva.

The anatomical changes attending parotitis are a serous or cellular inflammatory infiltration of the intralobular and perilobular connective tissue. This inflammatory swelling either disappears entirely, frequently leaving behind an induration of the connective tissue, or the serous-cellular infiltration breaks down and becomes purulent, causing abscess or sloughing of the parotid (suppurative or septic parotitis).

The clinical course of epidemic parotitis or mumps is as follows: The illness begins, after a certain period of incubation (indigestion, nausea, vomiting, and often diarrhœa), with fever and severe pain in the parotid, so that opening the mouth, mastication, and swallowing are difficult. The disease is most common among children from two to sixteen years of age. The swelling of the parotid is usually marked, and it develops very quickly. Both glands are affected, as a rule, either simultaneously or one after the other. The duration of the disease is about a week, sometimes more, but at the most two weeks, when, for instance, both glands are not affected at the same time, but the inflammation of one follows that of the other. Complete restitution is the usual result, and suppuration scarcely ever occurs. Parotitis is sometimes complicated by inflammation of the testicle (orchitis), and of the right testicle more frequently than of the left. Inflammation of the epididymis (epididymitis) and of the spermatic cord is less frequent. Sometimes, however, inflammation of the urethra, with a gonorrhœa-like discharge and inflammatory œdema of the scrotum, is observed. In women there is sometimes swelling of the breasts and of the external genitals and ovaries, with a vaginal and uterine discharge. These complications of the male and female genitals also disappear, as a rule, quickly and completely.

The prognosis of mumps is altogether favourable.

The treatment of mumps consists in confining the patient to bed, in giving a suitable diet, and in cleansing the mouth with disinfecting washes. Hucter recommends very highly parenchymatous injections of a from two- to three-per-cent solution of carbolic acid by means of a hypodermic syringe. In case of considerable fever, antipyretic remedies may be used. Orchitis is treated by elevating the testicle and applying ice. For the discharge from the urethra, chlorate of potash is given internally, as well as an abundance of water containing carbonic acid. In women the inflammatory complications on the part of the genito-urinary organs are to be treated upon similar principles.

Suppurative parotitis, which, as we saw, occurs in connection with septic, pyæmic intoxications and other acute infectious diseases, is characterized by high fever, which is usually accompanied by delirium, and it is always to be regarded as a dangerous disease. The swelling of the glands and the œdema of the surrounding tissues may become extreme, especially in the direction of the pharynx and the entrance to the larynx, so as to render respiration difficult. There is usually at the beginning diffuse swelling without distinct fluctuation, caused by a diffuse inflammatory or suppurative infiltration within the capsule of the gland. If an incision is not made at the right time, the capsule of the gland and the enveloping fascia is broken through by the diffuse suppurative process, and the pus spreads to the immediate surroundings—e. g., downward between the muscles of the neck, or upward to the base of the skull and into the cranial cavity, so that death may ensue from suppurative meningitis and sinus thrombosis. One also observes very frequently perforation of the pus into the external auditory canal or the pharyngeal cavity, or externally through the skin. The course of the disease is then sometimes very prolonged, and may extend over weeks or months, until the entire parotid is destroyed by the suppurative and gangrenous process.

The prognosis of suppurative parotitis depends partly upon the existing constitutional disease (sepsis, pyæmia, and other acute infectious diseases) and partly upon early incision of the parotid.

The treatment of suppurative or septic parotitis must be as energetic as possible. If, in the course of the above-mentioned infectious diseases, swelling and tenderness of the parotid occur, accompanied by a rise of temperature, an incision must be made at once with the aid of an anæsthetic. The most serviceable method is to make several incisions in order to relax sufficiently the parotideo-masseteric fascia. The incisions should be made over the softened areas. The skin and the fascia are divided from above downward with the knife, and the opening is enlarged with closed dressing forceps or an artery

clamp. Injury to Steno's duct, the facial nerve, the temporal artery and the transverse facial at the lower border of the malar bone, of the external carotid artery, and the temporo-maxillary vein at the posterior edge of the ascending ramus of the jaw, can easily be avoided. If necessary, short, wide drainage-tubes are placed in the openings made by the incisions, the pus cavity is irrigated with a 1-to-1,000 bichloride solution, and a light antiseptic dressing applied which should be frequently changed during the next few days. In case of extensive gangrenous destruction, the use of iodoform and simply covering the sloughing area with wet antiseptic compresses are to be recommended. One must constantly guard against burrowing of pus. If the infectious disease which is present runs a favourable course, healing usually follows very gradually after expulsion of the broken-down tissue of the parotid. There is also an acute inflammation of the submaxillary gland analogous to epidemic and suppurative parotitis which can develop directly from the extension of an epidemic parotitis. The course and treatment are the same.

Angina Ludovici.—By angina Ludwigii, or Ludovici, so called after the Würtemberg physician Ludwig, who first described the disease, is understood an acute phlegmonous inflammation in the vicinity of the submaxillary gland which goes on to suppuration or gangrene. This periglandular phlegmon also appears sometimes as an epidemic, and less frequently occurs metastatically in connection with severe infectious diseases. The disease affects adults chiefly, but attacks children not infrequently, especially in their first year. There is generally at the outset an insignificant swelling on one side near the submaxillary gland, which is tender on pressure. This spreads rapidly, and the upper part of the neck and the floor of the mouth become firmly infiltrated. Opening the mouth, mastication, and swallowing are rendered difficult or impossible, and the swelling or œdema may become so great in the vicinity of the larynx as to cause suffocation from œdema of the glottis. There is often a very high temperature. In case proper treatment is employed, recovery usually takes place by absorption of the exudation or the formation of an abscess. If an incision is not made at the proper time, extensive suppuration or sloughing and death from sepsis and pyæmia may ensue. The latter is also to be feared in case of suppurative breaking down of a thrombus in the facial vein, which crosses the outer surface of the submaxillary gland.

The treatment of angina Ludovici is the same as that of suppurative parotitis (see page 489).

Primary acute inflammation of the sublingual gland is rare; it is sometimes observed in connection with epidemic parotitis (sublingual

mumps), and is characterized by a painful swelling of the floor of the mouth in the region of this gland. The etiology is the same as that of parotitis, and the treatment conforms to general rules.

Of other inflammations of the salivary glands, those that occur in the course of syphilis are especially to be mentioned—e. g., gummatous infiltration with breaking down of the substance of the glands and cicatricial contraction, and the rare cases of tubercular caseation of the salivary glands. Stubenrauch observed a case of tubercular parotitis with cyst formation resembling an ordinary salivary cyst.

Mikulicz, Fuchs, and Haltenhoff observed cases of painless swelling of both lacrymal glands, with subsequent marked swelling of both parotids, submaxillaries, sublinguals, the palatine glands, and the accessory salivary glands in the cheek. Mikulicz's patient died of peritonitis. The microscopic examination of these glands revealed small-celled infiltration of the interstitial connective tissue, the parenchyma being uninvolved. This case was probably one of a peculiar form of parasitic infection which began in the excretory ducts of the lacrymal and salivary ducts, attacked the lacrymal and salivary glands themselves, and then involved the smallest lymphatic structures with their surrounding and permeating connective tissue, and in this way led to general infection and fatal peritonitis (see Mikulicz, Beiträge zur Chirurgie, Billroth's Festschrift).

§ 84. **Retention of Secretion in the Ducts of the Salivary Glands.—Salivary Concretions.—Foreign Bodies in the Salivary Ducts.**—Retention of secretion in the ducts of the salivary glands is caused principally by contraction or complete obstruction of the excretory ducts—e. g., by salivary concretions or foreign bodies that have made an entrance. In consequence of obstruction to the escape of the secretion, the ducts become more and more dilated till cysts varying in size are formed. Salivary duct-cysts and salivary gland-cysts may be distinguished, depending upon whether the dilatation affects the duct or the gland itself. The cystic formations resulting from retention of the secretion in the glands, as well as in the ducts, are comparatively rare, as the discharge of the saliva is usually not completely prevented. To salivary duct-cysts belong also, as we saw, some of the cysts situated beneath the tongue, to which the name ranula is given. We saw (page 384) that the ranula, according to Recklinghausen's careful investigations, is a retention cyst of the mucous gland at the tip of the tongue. In rare cases analogous ranula-like cysts develop beneath the tongue near the frenum from obstruction of Wharton's and Bartholin's ducts, or they may be dermoid, branchiogenic, or parasitic cysts.

Salivary cysts that develop in the glands themselves from retention of secretion are very rare, and are, of course, to be distinguished from cystic neoplasms.

Salivary duct-cysts and salivary gland-cysts are treated practically like ranula (see page 385)—that is, briefly stated, by incision and as complete extirpation of the sac as possible. Obliteration of the cysts by injection of absolute alcohol or tincture of iodine is not so reliable.

Salivary Concretions.—Salivary concretions consist chiefly of the phosphate and carbonate of lime. The deposit of lime sometimes takes place about a foreign body which has gained access to the excretory duct of the salivary glands (see page 493). Much more frequently, however—as a rule, in fact—there is no such foreign body present as a nucleus, and in these cases the formation of the concretions is hard to explain. According to Klebs, microbes are the principal cause of the deposit of the lime salts. It is possible that the bacteria cause a chemical change in the saliva. Salivary concretions may result from any cause that hinders or prevents the escape of saliva (Marcau). The occurrence of concretions within salivary cysts is also to be explained in this way. Genzmer has drawn attention to the fact that tartar on the teeth sometimes makes its way into Wharton's duct, where the concretions are most frequently found, and forms the nucleus for salivary concretions. In my opinion, salivary concretions are for the salivary ducts the same that tartar is for the teeth. Many persons, as is known, secrete saliva that contains a large percentage of lime. Such persons are therefore predisposed to tartar formation, and these deposits are sometimes formed in the salivary ducts. Regarding the comparative frequency of salivary concretions in the different salivary ducts, statistics collected by Czygan show that, of thirty-seven concretions, twenty-six were in Wharton's duct, four in Steno's duct, five in the ducts of Rivini, and one each in the parotid and in Bartholin's duct. The male sex is more subject to their formation than the female.

Salivary concretions are usually long, spindle-shaped, or more nearly round, the size of a pea or bean, less frequently of a walnut, though sometimes still larger. The surface is more commonly uneven than smooth. The escape of saliva is, as a rule, not wholly prevented by a concretion lying in a salivary duct. The principal discomfort consists in interference with mastication and speech, the latter being especially affected by concretions in Wharton's duct. Concretions in this duct are, in rare cases, directly visible. The presence of the concretions can usually be made out by palpation under the tongue or on the cheek, or by passing a probe through the salivary duct that is involved (see above, § 81, page 484, Anatomy of the Salivary Glands).

The treatment of salivary concretions consists in incising the mucous membrane directly over the stone and extracting it. The slight wound heals quickly with the use of antiseptic washes, and the saliva

usually flows again from the normal orifice of the salivary duct. If the incision remains open and the saliva discharges here into the mouth, it is, of course, of no special significance. If the concretions can not be removed from the gland—e. g., from the submaxillary gland—the latter should be extirpated from the outside, together with the concretion.

Foreign bodies occasionally enter the excretory ducts of the salivary glands—straws, for example, corn fibres or so-called corn beards, fish bones, bits of bone, etc. We mentioned above that in rare cases phosphate of lime and carbonate of lime are deposited around such foreign bodies in the salivary ducts, and that they may thus become nuclei of salivary concretions.

The treatment consists in the extraction of the foreign body, incising, if necessary, the mucous membrane, just as in the case of a salivary concretion.

A collection of air in the parotid has been repeatedly observed in case, for instance, Steno's duct has become rigid in consequence of chronic inflammation, so that its orifice does not close, but remains patent, and allows air to enter the duct without difficulty during speaking, and to pass on into the principal branches of the duct and into the lobules of the gland. C. Walther has described four characteristic cases of this kind. In two of these cases the whole parotid was inflated. In other cases we have to do with the formation of gas in connection with a septic inflammation.

§ 85. **Tumours of the Salivary Glands** are of great variety, and it is here that one finds, in the parotid, for instance, very interesting mixed tumours, which consist most commonly of cartilaginous, myxomatous, and sarcomatous tissue. Among tumours of the connective-tissue type, enchondromata, fibromata, myxomata, and sarcomata have been most frequently observed. It is in the salivary glands that the so-called cylindroma has been chiefly found (see Principles of Surgery, page 768). Pure or mixed cartilaginous tumours (enchondromata) of the parotid and submaxillary glands, which are so common, are probably to be traced to fœtal remains of cartilage from the first or second branchial arch.

Among epithelial tumours, adenomata, cysto-adenomata, and carcinomata are the most common. These epithelial neoplasms sometimes form interesting mixed tumours; in a carcinoma, for example, sarcomatous or cartilaginous areas may be found. Nasse made a careful examination of forty-six tumours of the parotid, and found four to be simple adenomata, two sarcomata, two carcinomata, and the remainder benign connective-tissue tumours, some of which were mixed forms (chondroma, myxoma, fibroma, cylindroma, endothelioma, etc.).

Tumours of the parotid are by far the most common.

Tumours of the salivary glands are rare among children, being confined chiefly to older persons. They can generally be easily distinguished from ordinary lymphomata, which usually consist of separate circumscribed nodules.

Tumours of the salivary glands, especially those of the parotid and the submaxillary (Fig. 272), form at first circumscribed intraglandular nodules, which then enlarge more and more, and may finally attain a great size. Enchondromata, fibromata, and myxomata grow at first very slowly, so that in a number of years only comparatively small tumours are formed. These tumours, which are at first benign, often begin to grow more rapidly because they change into more or less malignant tumours, especially sarcomata. This fact shows that fibromata, enchondromata, and myxomata, which are at the outset non-malignant, should also be promptly extirpated.

Fig. 272.—Fibro-chondro sarcoma of the submaxillary gland of eighteen years' duration in a man fifty-four years of age; extirpation; permanent cure during the past eight years.

The harder a tumour is the less malignant it is, as a rule. Malignant tumours of the parotid—e. g., carcinomata—become adherent to the skin comparatively early, and may then soon break through externally, or they may grow in the direction of the spheno-maxillary fossa or toward the nasal cavity. They frequently occasion severe pain from pressure upon the large vessels and nerves of the neck. Paralysis of the facial nerve also occurs, so that the mouth is drawn toward the sound side and closing the eyes is impossible, in consequence of paralysis of the orbicularis palpebrarum muscle. After a carcinoma breaks through the skin the condition of the patient becomes very pitiable in consequence of the sloughing and frequent hæmorrhages, and death usually soon follows from increasing marasmus, sepsis, hæmorrhages, etc.

The treatment of tumours of the salivary glands consists in their earliest possible extirpation. Even those which are at first benign should, as has been said, be promptly removed, inasmuch as they may become malignant, and then rapidly increase in size.

So long as the tumours remain intracapsular, extirpation is comparatively easy. All injuries to the neighbouring structures must be as carefully avoided as possible during the operation. Through a sufficiently large incision in the skin small nodules may be removed

within their capsule after dividing the latter. In case of larger tumours, one must always keep outside the capsule, freeing it with a blunt instrument from its surroundings and making use, when necessary, of the knife or the curved scissors. The vessels are caught with artery clamps before they are cut, tied in two places, and then divided between the ligatures.

If soft malignant tumours—e. g., carcinomata—have already broken through the capsule and have spread from the parotid, for example, in the direction of the spheno-maxillary fossa and the pharyngeal cavity, if there are infected lymph glands, or if there is extensive sloughing in consequence of breaking through the skin, an operation is contraindicated, and the treatment should be merely symptomatic. There is a prospect of complete cure in any malignant tumour so long as the capsule of the parotid or the submaxillary is not broken through. In such cases very satisfactory and permanent results may be attained by complete extirpation of the parotid and the submaxillary (see Fig. 272).

§ 86. **Removal of the Parotid and the Submaxillary Glands.**—Extirpation of the parotid is one of the difficult operations. As we have already seen, the external and internal carotids may be injured. Of smaller arteries, the transverse facial, the temporal, the posterior auricular, the arterial branches supplying the parotid, and sometimes also the occipital, come into consideration. The facial nerve is necessarily divided, as it is impossible to dissect the tumour away from it during extirpation of the whole parotid. Sometimes the paralysis of the muscles of the side of the face that is involved is not permanent, and innervation may be more or less completely restored.

The technique of extirpation of the parotid is as follows: The incision through the skin extends more or less perpendicularly downward over the full extent of the tumour. The latter must not be cut into. Any adherent portions of the skin are included within two elliptical longitudinal incisions. The auditory canal must be plugged with cotton and protected from irrigations during the operation. In the further course of the operation one should always keep outside the capsule. The operation is performed with blunt instruments so far as possible, scissors or the knife being used where necessary. The lower edge of the capsule or tumour is first exposed, and it is drawn upward with sharp hooks. The external carotid artery and the facial vein are looked for at the lower edge of the gland. If it is found that the external carotid will have to be cut, two ligatures are applied and it is divided between them. Some surgeons pass a ligature behind it, so as to be able to tie it quickly should it become necessary later. The gland is freed in the same way in front and above. Each vessel in turn is

caught with two artery clamps and then cut between them. An effort should be made to spare the main trunk of the facial nerve as much as possible so far as it lies outside the tumour. Finally, if the gland or the tumour is still firmly attached within the spheno-maxillary fossa, the removal of this part of the tumour is the most difficult, and must be done very cautiously. The temporal, the external and internal carotids, and the internal maxillary arteries may here be wounded.

Finally, the wound is thoroughly irrigated with a 1-to-1,000 bichloride solution, drained at its lower angle, and closed by a few tension sutures of silk and a continuous catgut suture, or packed with sterilized gauze. An aseptic protective dressing is applied, which includes the head and neck and, if necessary, the chest (see Fig. 3, page 10).

Removal of the submaxillary gland is much easier. It is only covered by the platysma and cervical fascia, and lies, as we saw, between the border of the lower jaw and the digastric muscle. The facial artery on the outer surface of the gland is caught with two artery clamps, divided between them, and tied. The facial vein can easily be spared, as well as the hypoglossal nerve at the lower edge and the lingual nerve at the upper edge of the tumour. The blunt enucleation of the gland may be facilitated by pushing it somewhat downward and forward from within the mouth.

SECOND SECTION.

SURGERY OF THE NECK.

CHAPTER X.

INJURIES AND SURGICAL DISEASES OF THE NECK (EXCLUSIVE OF THE CERVICAL VERTEBRÆ).

Congenital and acquired deformities of the neck (malformations).—Congenital fistulæ of the neck.—Torticollis (caput obstipum).

Injuries of the neck: Subcutaneous injuries (contusions).—Fractures of the hyoid bone, the larynx, and the trachea.—Burns (cicatricial contractions).—Wounds of the neck. Wounds of the arteries and veins: Ligation of arteries (innominate, subclavian, common carotid, external and internal carotid, superior and inferior thyroid, and vertebral). Injuries of the nerves and operations upon the nerves in the neck.—Wounds of the larynx, trachea, and œsophagus.—Inflammation and suppuration in the neck.—Aneurisms.—Tumours.—Bursal hygroma.

Diseases of the thyroid gland: Anatomy and physiology of the thyroid gland.—Inflammations.—Tumours (goître, malignant tumours, etc.).—Treatment of goître.—Extirpation of the thyroid gland and its results.

Injuries and diseases of the thymus gland.

§ 87. **Congenital and Acquired Deformities of the Neck.**—Congenital malformations of the neck depend upon disturbances in the normal development of the neck. The latter is formed, as is well known, by the coalescence of the so-called visceral or branchial arches in the median line. Four visceral or branchial arches are usually distinguished, and the same number of visceral or branchial clefts or furrows (His) between the arches. The fourth visceral arch, however, is not plainly demonstrable as such, according to Kölliker, in the chicken and rabbit. The first visceral arch has nothing to do with the formation of the neck. It gives rise to the upper and the lower jaw (see page 184). If in the second month of fœtal life the lower visceral arches do not close normally and completely, but remain partly open, a so-called branchial fistula results.

Congenital branchial fistulæ (*fistulæ colli congenitæ*) are divided into lateral and median fistulæ (Heusinger, Luschka, Ascherson).

The lateral branchial fistula of the neck may form a complete abnormal canal with external and internal orifice. The latter always opens into the pharynx, and always corresponds, no doubt, to the second visceral cleft (Heusinger, Fischer). The position of the external opening is very variable, according as this or that branchial cleft remains open. It lies most frequently in the region of the fourth branchial cleft near the sterno-clavicular articulation, or of the second or third branchial cleft—that is, at the inner or outer edge of the sterno-mastoid muscle and in the vicinity of the larynx. The fistulæ in the neighbourhood of the ear depend upon abnormalities of the first branchial cleft.

Incomplete congenital fistulæ of the neck form narrow canals with only one opening. The incomplete external ones have only an outer opening, and the incomplete inner ones only an inner opening in the direction of the pharynx.

The orifice of the complete and the incomplete internal fistulæ in the pharynx is usually in its lower part or in the posterior palatine arch near the tonsils. Congenital diverticula of the œsophagus are probably always incomplete lateral branchial fistulæ of the neck. Lateral fistulæ never open into the larynx.

The pathogenesis of branchial fistulæ has received considerable modification in consequence of the important discovery by His of the closing membrane within the branchial clefts, and through the labours of Rabl, Kotschenko, and others. Complete fistulæ of the neck ensue when His's membrane and the external and internal branchial clefts remain open. If this membrane remains closed and the internal cleft is obliterated while the external cleft remains open, there results an incomplete external fistula (Schnitzler, Sachs). The origin of congenital fistulæ of the neck may also, according to W. His, have some connection with the ductus thyreoglossus which at a certain period leads from the foramen cæcum into the median anlage of the thyroid gland.

Median fistulæ of the neck or fistulæ of the trachea are, according to Heusinger, very rare. They are to be regarded, according to Strübung, as lateral fistulæ of the neck with an opening in the median line, and their origin is that given above. Here also are found either blind external or internal fistulous tracts of different lengths, or complete canals with external and internal orifices. The latter are always found in the trachea or above the larynx. Incomplete internal fistulæ of the trachea may give rise to air tumours or laryngoceles (see page 562).

Fistulæ of the neck in the vicinity of the interclavicular notch of the sternum likewise owe their origin to branchial clefts.

All congenital fistulæ of the neck have the form of narrow canals lined with mucous membrane through which a probe or fine bristle may be passed. In the vicinity of the external opening of the fistula a protruding fold of skin is frequently found, and above the fistula, corresponding to its course, there is sometimes a hard, movable, fibrous, cartilaginous, or more bony body to be felt, which Heusinger designates as visceral bone and explains as a proliferation of fœtal branchial cartilage.

There is usually but little discomfort occasioned by congenital fistulæ of the neck. The passage of a probe may, as an exception, be very painful.

The secretion of the fistulæ is sometimes slight and sometimes more abundant, according to the greater or less abundance of the mucous glands. Accessory acinous glands have also been seen to communicate with the fistulous tracts, so that a comparatively complicated structure may result (Lejars). The secretion is usually a clear, colourless, odourless, and viscous fluid. In case of complete fistulæ, portions of food—especially fluids, or bread crumbs as well—sometimes escape from the pharynx. From obstruction of the external opening an accumulation of the secretion results and small cysts are formed. If the inner opening of a fistula in the pharynx or œsophagus leads to the formation of a diverticulum, great difficulty in swallowing then ensues, and the food that has been taken is, after a certain time, regurgitated. As we shall see when treating of diverticula of the œsophagus (§ 112), the dysphagia in these cases is, under certain circumstances, such as to endanger life. Incomplete internal fistulæ of the trachea may give rise to circumscribed air tumours (Madelung).

Lateral and median branchial fistulæ of the neck frequently do not come under surgical treatment, as they may cause no real discomfort. Small incomplete external fistulæ are cured by dividing them and excising the lining of mucous membrane. The injection of tincture of iodine is less reliable. If there is retention of secretion in consequence of closure of the outer opening, the excretory duct should be divided and the retained secretion allowed to escape. I have repeatedly secured permanently good results by the division and excision of such cystic formations with blind external or internal canals.

In suitable cases complete branchial fistulæ of the neck should be completely extirpated. Chalot successfully treated such a fistula as follows: 1. Freshening and suture of the internal orifice of the fistula from within the mouth. The orifice usually lies behind and below the lower portion of the tonsil, sometimes on the free edge of the posterior palatine arch, sometimes in front of and sometimes behind it. 2. Extirpation of the fistulous tract from the outer opening of the fistula as far as the greater cornu of the hyoid bone or somewhat higher. 3. scraping out the remaining upper part of the tract as far as the closed inner opening of the fistula. 4. Suture of the wounds in the soft parts, with the exception of a small opening at the level of the greater cornu of the hyoid bone, to allow the discharge of any secretion that may still remain. This part heals later by granulation.

With reference to congenital branchial cysts, the reader is referred to § 96 (Tumours). They lie, as a rule, behind the muscles of the tongue and the larynx, always in a median direction from the sterno-mastoid muscle, and develop in and out of the fœtal branchial cavity.

The formation of abnormal appendages of skin, which has already been mentioned, depends upon anomalies in the closure of the branchial arches. They are analogous to the neck appendages of goats and swine.

The above-mentioned visceral bone or visceral cartilage also occurs in rare cases without fistula formation—e. g., in the region of the middle and lowest branchial arch. It is formed from the proliferation of strayed fœtal cartilage cells.

Torticollis (Caput Obstipum), or Wryneck (see Fig. 273), is either congenital or acquired, in which case it is most commonly a result of cicatricial contraction of the sterno-mastoid muscle and of the cervical fascia, resulting from contusion or laceration of these parts during delivery (Stromeyer). Such injuries to the soft parts of the neck are caused chiefly by careless and too forcible extraction of the head in cases of breech presentation, and less frequently in cases of delivery by forceps. Petersen particularly has emphasized the view that in such cases there is usually a congenital shortening of the sterno-mastoid muscle, while Witzel, for instance, has defended the purely traumatic origin of torticollis *inter partum* in Stromeyer's sense. According to Mikulicz and Beely, torticollis in its severe forms is to be regarded as an ischæmic contracture (see § 297, Ischæmic Contractures of the Forearm), caused by pressure on the sterno-mastoid muscle *inter partum.* The hæmatoma, moreover, which is formed in the firm fibrous sheath of the muscle, from compression and stretching of the latter, probably exerts an injurious pressure on the muscular fibres, causing ischæmic degeneration.

Fig. 273.—Torticollis or wryneck.

In distinction to the cases of wryneck occasioned by injury during delivery, the exclusively congenital cases originating *in utero* are infrequent. Petersen has collected ten cases of the kind. In six of them there existed simultaneous obliquity of the face. Asymmetry of the skull has also been recently observed in several cases of torticollis. Heusinger observed wryneck in a newborn child some days after birth, and he demonstrated that the sterno-mastoid muscle on the left side, which had undergone a fibrous change, was two and a half centimetres shorter than that on the right. I agree with Petersen in the opinion that torticollis may arise simply from continued oblique position of the head owing to adhesions of the amnion *in utero*, in which case the sterno-mastoid muscle does not undergo the fibrous changes that are found in the torticollis due to injury to the muscle *inter partum.* We may have to do in such cases with a fœtal rhachitis causing curvature of the cervical vertebræ (Phocas, author).

The affection sometimes arises also from cicatricial contraction of the platysma resulting from injury to the same, likewise during birth (Gooch).

The development of torticollis *inter partum* from contusion and laceration of the cervical fascia and the sterno-mastoid muscle is usually as follows:

Some days after birth an effusion of blood at the point where the injury was received becomes demonstrable, sometimes circumscribed, and sometimes involving the entire sterno-mastoid muscle. This extravasation of blood and the injury which caused it are very often overlooked. The hæmatoma becomes in its further course harder, and then, often some weeks after birth, is noticed by the mother, it may be while bathing the child. The oblique position of the head becomes more and more marked, corresponding to the cicatricial contraction of the injured sterno-mastoid muscle and the cervical fascia. The affection is often first discovered when the children are older and begin to hold the head upright. After several years the head is plainly inclined to the diseased side (Fig. 273). The sterno-mastoid can be felt on the affected side as a hard, fibrous cord, especially at the lower portion near its origin from the clavicle and sternum.

After the affection has lasted for some time, secondary changes take place in the cervical and thoracic vertebræ, resulting from disturbances in their growth—that is, scoliosis of the cervical portion of the spinal column, and compensating scoliosis of the dorsal portion toward the opposite side. The cervical vertebræ gradually become wedge-shaped, corresponding to the permanent lateral flexion of this portion of the spinal column, because their growth upon the diseased side is diminished by pressure. The deformity also makes itself apparent through obliquity of the articulation between atlas and axis.

As further secondary changes after many years' duration of torticollis, contractures of all the soft parts upon the affected side ensue, especially of the other muscles of the neck, the fasciæ, the vessels and nerves, and finally asymmetry of the head and face results. The half of the face on the diseased side is usually smaller, and the lower jaw is plainly oblique. Hübscher has described a symmetrical limitation of the fields of vision in connection with torticollis.

Torticollis seems to occur more frequently on the right side than on the left. Contracture of both sides, with a drawing down of the chin toward the neck, is very rare. The degree of contracture is very variable.

Aside from congenital torticollis and that acquired *inter partum*, the same affection may occur later in life from cicatricial contraction

following wounds and inflammations, especially after burns, lupus, cellulitis with deep suppuration, after necrosis of tissue, from inflammation, paralysis, or spasmodic conditions of the muscles, especially the sterno-mastoid and trapezius, in consequence of irritation of the spinal accessory nerve (spastic torticollis), from tumours (sarcomata) of the sterno-mastoid, and finally from diseases of the cervical vertebræ and their articulations (rhachitis, tuberculosis, dislocation of the same). Functional torticollis is observed after paralysis of the muscles of the eye. A. Nieden has collected eight cases of this kind from the literature of the subject in addition to one that he observed himself.

The treatment of the various forms of torticollis depends largely upon their cause.

We shall occupy ourselves here especially with the treatment of the purely congenital form and that acquired *inter partum* and due to cicatricial contraction of the sterno-mastoid muscle.

The sooner after birth this deformity comes under proper treatment the better. In recent cases of injury to the sterno-mastoid muscle the effusion should be removed by massage as soon as possible, and then a piece of pasteboard or leather made in the form of a collar and filled with cotton should be laid about the neck of the child, in order to prevent cicatricial shortening. This must be worn for some time. It is a good plan to make it somewhat higher on the side that is affected, in order that the head may incline rather to the sound side. This overcorrection of the deformity adjusts itself later. In the early stages stretching the cicatrix by permanent traction with Glisson's sling is to be recommended (see Surgery of the Spine).

In case of fully developed torticollis, operative treatment is necessary, and in this way, with proper after-treatment, recurrences are most surely prevented. The operative treatment of torticollis consists in subcutaneous tenotomy of the sterno-mastoid muscle with some form of orthopædic after-treatment, as recommended by Dupuytren, Dieffenbach, and Stromeyer, or, better, in open division of the cicatrix after it has been exposed by a longitudinal incision (see page 503). Children are operated upon in severe cases as early as the end of their first or second year or even earlier. Parents, however, do not, as a rule, consent to an operation until later, when the affection goes on getting worse in spite of orthopædic treatment.

Subcutaneous tenotomy of the sterno-mastoid muscle is performed under an anæsthetic after thoroughly cleansing with soap, shaving, and disinfecting the field of operation. By flexing the head toward the sound side, the shortened sterno-mastoid muscle is put on the stretch at its lower part and at its point of origin on the sternum and clavicle,

so that it stands out more prominently. The muscle is then raised with the thumb and forefinger from the underlying parts, in children one centimetre, and in adults two centimetres above its origin. An aseptic tenotome is then introduced on the right sterno-mastoid from the median side, on the left from the outer side. After the tenotome has been pushed behind the muscle with its flat surface parallel to the muscle, the edge is turned forward, the point of the knife is controlled by the thumb or forefinger of the left hand, and finally the muscle is divided, the ends of which can be felt to recede. One must always be careful that all the fibres of the muscle are cut. After the division has been made, the knife is drawn from the puncture opening, and the latter is immediately covered with a piece of sterilized gauze and an antiseptic protective dressing is applied so as to include the head, neck, and thorax. In applying the dressing the head is inclined somewhat toward the sound side.

Usually only the sternal portion of the muscle is divided subcutaneously. If necessary, its clavicular insertion is severed in the same way. The external jugular vein has sometimes been injured in this operation, but this can easily be avoided. It is sometimes necessary to divide the clavicular origin of the muscle only.

I never perform subcutaneous tenotomy, but always expose the lower portion of the muscle by means of a longitudinal incision under antiseptic precautions, and then divide the shortened muscle and the tense cicatricial bands in the vicinity, and particularly the contracted fasciæ, until the head can be completely flexed toward the sound side. Immediately after the operation and during the after-treatment the scoliosis of the cervical vertebræ should be corrected manually as far as possible, this being, as Lorenz in particular has shown, of great importance for a permanently good result.

This method is much surer than simple subcutaneous tenotomy, and one can always ascertain, in older children at least, that not only the sterno-mastoid muscle but the superficial and deep fascia as well are shortened, and that these cicatricial bands must likewise be divided. The latter, however, usually remain uncut in subcutaneous tenotomy.

After drainage and suture of the wound, an aseptic protective dressing is applied about the head, the neck, and the thorax in such a way that the head is inclined toward the sound side. After the wound has healed, if the case is a severe one, permanent extension by means of Glisson's apparatus is employed for about a fortnight in the manner described above, with inclination of the head toward the sound side, and then a simple leather collar is worn for a time, or the collar represented in Fig. 274, the edge of which is higher on the diseased side

than on the sound side. I lay great stress upon the use of massage and upon gymnastic exercises. In milder cases and in treating younger children where there is as yet no deformity of the cervical vertebræ, I content myself with simple division of the muscle. All after-treatment is then unnecessary if all the cicatricial bands have been divided. Mikulicz has recently removed the entire sterno-mastoid muscle in bad cases of wryneck and secured permanently good results.

FIG. 274.—Apparatus for the after treatment of torticollis.

The treatment of other forms of torticollis is directed mainly against the underlying cause. It consists, therefore, in extirpation of cicatrices in the skin and covering the defect by a plastic operation, or in stretching more deeply situated cicatrices by permanent extension by means of Glisson's apparatus, or in overcoming any paralysis that may be present, etc. In case of spastic torticollis, stretching and excision of a portion of the accessory nerve has been undertaken with success (see page 529). Cures have been observed after stretching as well as after neurectomy, and Schwartze recommends combining the two—that is, performing neurectomy after stretching the nerve. For a description of torticollis resulting from diseases and dislocations of the cervical vertebræ, see Surgery of the Spine.

§ 88. **Injuries of the Neck.**—Injuries of the neck are in part subcutaneous and in part open wounds. The most important injuries are those of the vessels, the nerves, the trachea, and the œsophagus.

Contusions.—Subcutaneous injuries of the neck or contusions arise chiefly through blunt violence—e. g., from a blow, a kick, or from being run over, or, again, from throttling, strangling, and hanging. A blow or pressure upon the larynx may give rise to a sudden reflex attack of suffocation from spasm of the glottis, without a fracture of the cartilage of the larynx or any other injury to the larynx or trachea. The most extensive injuries to the neck occur particularly from the passage of a wagon wheel over the neck or from machinery—e. g., fractures of the spinal column and the laryngeal cartilages, laceration of the large vessels, the nerves, the larynx, the trachea, and the œsophagus. Noll observed subcutaneous separation of the trachea from the larynx, with scarcely an injury to the outer covering of soft parts, in the case of a workman in a manufactory whose cravat was caught by a transmission bar. Recovery ensued after tracheotomy, but, on account of subsequent laryngeal stenosis, division of the larynx (laryngotomy) was afterward necessary. In cases of throttling, strangling, and

hanging, death ensues from asphyxia, as the entrance to the larynx is closed by pressure of the base of the tongue against the posterior pharyngeal wall. In hanging, death is also caused by injury of the cervical portion of the vertebral column and the spinal cord, and by dislocation of the cervical vertebræ.

In connection with these three forms of death just mentioned the greatest variety of injuries is observed, including rupture of the intima of the carotids. It is a fact of some importance, from a medico-legal standpoint, that in cases of throttling the marks made by the pressure of the fingers can usually be distinguished, and that in cases of strangling, the groove made by the cord runs completely around the neck, while in case of hanging, the groove lies chiefly above the larynx, leaving the nape of the neck untouched. Death from hanging usually results very quickly. It is only in exceptional cases, as, for example, in one mentioned by Georg Fischer, that attempts to restore life by artificial respiration or by tracheotomy are successful five minutes after the hanging takes place. Sometimes those who are restored after hanging die a few days later from œdema of the lungs or thrombosis, or an aneurism develops in consequence of rupture of the intima of one of the carotids.

The treatment of contusions of the neck conforms to the rules applicable to subcutaneous injuries which are given in detail in Principles of Surgery (see § 92, page 504). Care is to be taken, above all, that respiration is not impeded, and it may therefore prove necessary to perform tracheotomy. In cases of hanging, strangling, and throttling also, opening of the trachea is indicated, for the purpose of making use of artificial respiration, just as in cases of drowning. All such attempts to restore life by means of artificial respiration must be continued for a long time (see particulars concerning artificial respiration in Principles of Surgery, § 13).

Among injuries to the neck from blunt violence, fractures of the hyoid bone, the larynx, and the trachea are of special interest.

Fractures of the Hyoid Bone.—Fractures of the hyoid bone are not frequent. They are caused chiefly by direct violence, from a kick or a blow, from hanging or throttling, or, less often, from muscular action. Fractures take place either through the body of the hyoid bone or the greater cornua. The displacement of the fragments is usually marked, and one can generally feel them from the outside or from the mouth, beneath the mucous membrane of the pharynx, for example.

The most important disturbance in connection with fractures of the hyoid bone is interference with respiration (dyspnœa) and with swallowing (dysphagia). The latter may become so marked that deglutition is

quite impossible. Speaking, also, and every movement of the head, the lower jaw, and the tongue are all very painful. Patients have sometimes a very hoarse speech or are completely aphonic. If the mucous membrane of the pharynx is injured, profuse hæmorrhage may take place from the mouth. At the site of the fracture there is usually a hæmatoma which is clearly perceptible from the outside. It is characteristic of fracture of the hyoid bone that the patient feels as though a foreign body like a large fish bone had stuck in the throat.

Fractures of the hyoid bone usually unite by the formation of a callus. Necrosis of a fragment is less frequent.

The treatment of fracture of the hyoid bone consists in replacing the dislocated fragments as far as possible from the pharynx and from the outside. The head and neck of the patient are immobilized as completely as possible. Retention of the fragments is, however, scarcely possible. In case of dyspnœa, tracheotomy may be found necessary. All movements of the neck, speaking, etc., are to be avoided as far as possible. The diet should consist of fluids, and they are best given at first through the stomach tube.

Dislocations of the Hyoid Bone.—Gibbs, Wood, and others have observed dislocation of the hyoid bone. In the case reported by Wood the dislocation happened in a phthisical subject during an attack of coughing while the head was inclined to the right side. The dislocation took place more easily in consequence of destruction of the larynx from tubercular ulceration. The hyoid bone was pushed to the left and there was great difficulty in breathing. By pressure toward the right and a simultaneous swallowing movement the bone sprang back into its normal position. The bone was maintained in position by pads secured in place on each side.

Fractures of the Cartilages of the Larynx.—Fractures of the larynx occur most frequently in older people whose cartilages have become calcified or ossified. They are most frequent in the thyroid and cricoid cartilages. The arytenoid cartilage is much less frequently affected. Fractures arise, like those of the hyoid bone, most commonly from violence so directed that the larynx is compressed laterally or from in front backward—e. g., by being run over. The cartilages of the larynx may be completely shattered as the result of very great force, or the entire larynx may, as stated, be torn away from the trachea. Fractures are frequently combined with injuries to the external or internal soft parts.

The symptoms of fracture of the laryngeal cartilages are swelling and deformity which are usually visible from the outside, severe functional disturbances, especially dyspnœa and very painful paroxysms of

spasmodic coughing, caused by dislocation of the fragments, aspiration of blood into the lungs, and by direct irritation of the sensory nerves of the larynx in consequence of the injury. The amount of aspirated blood may be such as to cause death from asphyxia. Swallowing is also impeded, but not to such a degree as in fracture of the hyoid bone. As the mucous membrane is usually ruptured, emphysema of the outer coverings ensues, which may spread rapidly over the face, the body, and the mediastinum, or even over the extremities.

The prognosis of fractures of the larynx is, according to the statistics of Durham and G. Fischer, very unfavourable. According to Durham, from a total of sixty-nine cases, fifty-three proved fatal. According to G. Fischer, fifty-nine cases out of seventy-five died. Death usually takes place promptly if medical assistance is not secured early enough, and is caused by suffocation, in consequence of the dislocated fragments and the aspiration of blood into the lungs, by increasing dyspnœa from œdema or spasm of the glottis, and also, no doubt, by mediastinal emphysema. According to Sokolowsky and U. Clarac, fracture of the cricoid cartilage is especially unfavourable, nearly every case being fatal. According to Sokolowsky, the literature of the subject gives but one case that resulted favourably.

Longitudinal fractures have, in general, a more favourable course than transverse fractures, because in the latter the displacement is greater.

If union of the fracture takes place, it is, as in all fractures of cartilage by the formation of a bony callus, which is usually small in amount.

The treatment of fractures of the larynx must be very prompt. Speedy tracheotomy is usually indicated, even though there be but slight difficulty in respiration, as attacks of suffocation may come on suddenly. Any displacement may be corrected through the wound made in performing tracheotomy by introducing a curved dressing forceps, and the blood that has flowed into the lungs may be removed by aspiration. If the fragments can not be successfully replaced through the wound in the trachea, the cricoid cartilage should also be divided in case the displacement is marked, and a part also of the thyroid cartilage if necessary. After the fragments have been replaced, an effort should be made to keep them in position by packing the larynx above the tracheal canula, by inserting a thick drainage-tube, or by catgut sutures. If there is difficulty in swallowing, the patient should be fed through the stomach tube. Resulting stenosis of the larynx must be treated later in accordance with general rules (see Diseases of the Larynx).

Dislocations of the Cartilages of the Larynx.—Dislocations of the various articulations of the larynx are very rare. Dislocations of the arytenoid cartilage and of the crico-thyroid articulation have occurred. H. Braun observed, on himself and in two patients, habitual dislocation of the joints between the inferior cornua of the thyroid cartilage and the cricoid cartilage. When this luxation of the crico-thyroid articulation occurs—e. g., in yawning or in deep inspiration—the patient feels at the site of the dislocation, sometimes on the right and sometimes on the left side, a severe pain, accompanied by a sensation of uneasiness or anxiety that always returns, even though he is convinced that the affection is of no significance. At the place in question a small projection may be made out which, by means of pressure outward and backward, can be made to disappear with a clearly audible sound. The dislocation may also be reduced by a few swallowing movements.

Fractures of the Trachea are much more rare than those of the hyoid bone and the larynx. They occur, as a rule, from severe injuries of the neck—e. g., from being run over. There may be either fractures of the tracheal rings from above downward, or transverse separation of the tracheal rings from one another or from the larynx. The bronchi or the trachea may also be torn from the lung near the point of bifurcation.


Fig. 275.—Cicatrices in a boy of five following a burn from boiling water.

The diagnosis of fracture of the tracheal cartilages may be made difficult by the presence of marked emphysema of the subcutaneous cellular tissue which usually occurs.

The treatment consists in prompt tracheotomy, if necessary, in order to facilitate respiration, to get rid of the aspirated blood, and to employ artificial respiration.

Burns of the Neck.—Cicatricial Contractions.—Burns of the neck occur most frequently among children, and may cause serious cicatricial contractions, so that, for example, the head is drawn down upon the thorax and fixed in this abnormal position (Fig. 275). It may happen in bad cases that the entire skin of the face is drawn downward more or less, the lower lip is everted, the mouth is open in consequence of the contraction of the lower jaw, and the cheeks and the lower eyelid are also drawn in the same direction.

The treatment of a burn should therefore be directed toward the prevention of such cicatricial contractions by transplantation of skin. If cicatricial bands running from the head to the neck are already

present, they must be divided or extirpated and an attempt made to cover the defect by pedunculated (plastic) flaps of skin from the surrounding parts, or by transplantation of large, very thin pieces of skin. P. Berger recommends, in case of cicatricial bands connecting the lower jaw and the clavicle, division of the cords by means of three H-shaped incisions, and freeing the cicatricial edges of the wounds by blunt dissection from the subjacent tissue for a sufficient distance to secure to the head its full freedom of motion. The large defect may then be covered by a flap which has its pedicle at the back of the neck, and, if necessary, another pedunculated flap may be taken from the skin of the thorax or from the shoulder. The flaps should contain as much skin, subcutaneous fatty tissue, and fascia as possible, to assure their subsequent mobility. In milder cases it is sometimes sufficient to stretch the cicatricial bands by permanent extension.

Wounds of the neck may be very complicated, as vital organs lie together here in a comparatively small space and have but little protection.

Accidental injuries of the neck from a thrust, a puncture, a cut, or shooting, are, generally speaking, infrequent. These wounds occur most frequently in cases of suicide and murder. Suicides who wish to cut their throats with a razor, for instance, miss the right place as a rule, especially the large vessels. Neck wounds of suicides usually run transversely or obliquely between the hyoid bone and the larynx, or form merely a superficial injury near the thyroid cartilage. Suicides, on the contrary, who have a knowledge of anatomy have killed themselves by puncturing the common carotid, or the internal carotid from within the mouth.

In murderous assaults one usually has to deal with punctured wounds in the side of the neck.

Gunshot wounds of the neck are not common even in war. Such wounds in the neck are in rare cases so-called contour shots, arising most commonly from spent balls, sometimes also from shooting at short range. Georg Fischer mentions several such cases. A case observed by Hennen is perhaps the best known. The ball entered above the pomum Adami, made a subcutaneous circuit of the entire neck, and lay in the opening where it entered. Baudens also saw a case of a student in which a ball from a pistol passed around the neck and was removed two centimetres from the place of entrance.

The course of wounds of the neck is very variable, and depends largely upon whether the main vessels, the nerves, the trachea, or the œsophagus are injured or not. From injury to the thyroid gland very severe and dangerous hæmorrhage may occur, and serious secondary

hæmorrhages follow. Before the use of antiseptics in surgery had become general, wounds of the neck had an unfavourable prognosis. Diffuse inflammation of the cellular tissue, with burrowing of pus into the mediastinum, often followed comparatively slight wounds, death ensuing from pyæmia and septicæmia.

As it is important, from a clinical as well as a therapeutic point of view, to know which structures of the neck have been injured, it will be well to take up separately wounds of the large vessels, the nerves, the trachea, and the œsophagus.

§ 89. **Wounds of the Arteries of the Neck.**—The neck contains many large and medium-sized arteries. I mention only the innominate, the subclavian, the common, external, and internal carotids, the superior and inferior thyroids, the vertebral, etc. Injuries to these arteries, however, are not very frequent, partly because their elastic walls are movable upon the subjacent parts, and are therefore easily pushed to one side by the force that inflicts the injury. In case of injury to a large artery of the neck, death follows quickly from hæmorrhage, especially when a free escape of the blood is not impeded, as, for instance, in the case of long incised wounds. If an artery is wounded by puncture or by shooting, hæmorrhage takes place chiefly into the surrounding tissue without an outward escape of the blood—that is, there arises a so-called traumatic aneurism, or, more correctly, a hæmatoma, which is sometimes small and sometimes of considerable size. In this way the hæmorrhage may cease spontaneously, and an aneurism is finally formed whose wall consists of the outer layers of the thrombus and the surrounding tissue. Simultaneous injury of an artery and of the vein lying near it may lead to the formation of a so-called arterio-venous aneurism or an aneurismal varix or varicose aneurism—that is, the vein and artery communicate at the point of the injury, so that the arterial and venous blood mingle (see Principles of Surgery, § 95, page 534 ff., Aneurisms). The extravasations of blood in the neck in consequence of injury to an artery may become so considerable as to compress the trachea, the larynx, the œsophagus, the veins, and the nerves, and occasion serious symptoms.

In case of gunshot injuries appreciable hæmorrhage may be absent at first, and dangerous secondary hæmorrhages may then arise in the course of the next five to ten or fourteen days, owing either to the fact that the merely contused wall of the artery has gradually broken through, or that the artery, otherwise uninjured, has been eroded by suppuration of the wound. If the wound is not treated with antiseptic precautions the suppuration may extend very rapidly and involve the mediastinum, causing death from pyæmia or sepsis.

The arteries which are to be specially considered in connection with injuries to the neck are the innominate, the subclavian, the common, external, and internal carotids, the superior and inferior thyroids, the lingual, the ascending pharyngeal, and the vertebral.

1. Injury to the innominate is rare. Erwin observed a case of injury to this artery caused by the blade of a pocket knife which had entered above the right sterno-clavicular articulation. The wounded person was able to walk fifty-nine yards at a rapid gait before bleeding to death. In exceptional cases the artery has been cut into during the performance of low tracheotomy, or afterward eroded through suppuration.

2. The subclavian may be injured above or below the clavicle, especially from a punctured, incised, or gunshot wound. This injury is also rare. The pleura is generally injured at the same time, and considerable hæmorrhage therefore takes place into it (hæmothorax).

In case of simultaneous injury to the artery and the vein, death does not always follow at once. Here also spontaneous arrest of the hæmorrhage is possible, and has been observed. According to G. Fischer, death is not infrequently delayed for eight or ten days, resulting then from secondary hæmorrhage. Richet observed recovery from compression of the artery. Recovery without ligation after a gunshot wound of the subclavian artery and vein was seen by O'Keefe in the American civil war. The brachial plexus is sometimes injured at the same time.

3. Injury to the common carotid is more frequent. In case of an incised wound, death usually follows within a few minutes, before a physician can be called. If the blood does not escape externally, a very large hæmatoma arises, so that death may ensue from compression of the respiratory passages, or recovery may follow from spontaneous arrest of the hæmorrhage. If there is a simultaneous injury of the internal jugular vein, death usually ensues immediately. Garrett saved a patient by compression who was almost moribund one and a half minutes after the injury.

4. Likewise in case of injury to the external and internal carotid there is violent hæmorrhage, and immediate assistance is necessary. Recovery has here also taken place from compression without ligation. Injuries to the internal carotid occur especially from wounds behind the jaw in the neighbourhood of the tonsils—e. g., from a fall upon some sharp object held in the mouth, or from a gunshot wound near the mastoid process. It is well known that the internal carotid is occasionally injured during an operation on the tonsils. This may occur in exceptional cases from drawing the tonsils out too far in performing amputation, particularly when the galvano-caustic loop is used. I have seen one such case in the practice of a colleague in which recovery took place from immediate ligation of the common carotid. The internal carotid may likewise be opened by erosion of the artery resulting from tonsillar abscess, carcinoma, suppurative adenitis, caries, or necrosis of the temporal bone.

The external carotid is still more easily reached in case of injury. If the artery is cut or punctured, the trunk and several branches are usually injured at the same time, so that the hæmorrhage is profuse.

5. The superior thyroid and the lingual arteries may be divided by sui-

cides in the attempt to cut the throat, and dangerous hæmorrhage may ensue.

6. G. Fischer quotes a case of fatal hæmorrhage from injury to the ascending pharyngeal artery caused by the tip of a pipe which, in consequence of a fall, had punctured the pharyngeal wall.

7. The vertebral artery (see Fig. 276), in spite of its very protected position, is not infrequently injured. This artery, which is the first branch of the subclavian, arises opposite the origin of the internal mammary. It lies at first beside the common carotid, then enters the vertebral foramen of the transverse process of the sixth cervical vertebra (the so-called carotid tubercle), passes through the vertebral foramina of the six upper cervical vertebræ, enters the cranial cavity, and joins with the artery of the other side to form the basilar artery.

Fig. 276.—Location of the vertebral artery after removal of the overlying soft parts (skin, muscle, fascia, and ligaments) [after Roser].

Georg Fischer found in the literature of the subject thirty-two cases of injury to this artery. In most cases it occurred in connection with a wound of the back of the neck. It is wounded most frequently near the atlas, but also between the other cervical vertebræ—e. g., from a gunshot injury, with shattering of the transverse processes of the vertebræ and laceration of the spinal cord. The vertebral artery has also been eroded in the course of spondylitis.

The prognosis of injury of the vertebral artery is less favourable than that of injury to the common carotid. Of thirty-two patients, only one, according to G. Fischer, recovered. The others all died, either within a few days in consequence of hæmorrhage, or later on from suppuration, septicæmia, and pyæmia.

The diagnosis of wounds of the arteries in the neck is usually easy. The profuse hæmorrhage or a quickly forming subcutaneous hæmatoma is characteristic. Still, it is possible to be left in doubt at first whether the artery or vein is injured. Which artery is injured is determined chiefly from the location and direction of the wound, from the amount of hæmorrhage, and from the absence of pulsation in the branches of the wounded trunk. The latter often allows, to be sure, only an uncertain conclusion, as the collateral circulation is frequently restored very quickly. If there is arterial hæmorrhage from the ear, one may conclude that there is an injury to the internal carotid or the middle meningeal.

Certain associated injuries, especially of the nerves, the trachea, and the œsophagus, are of great importance from a therapeutic standpoint as well as for other reasons. In connection with injury to the subclavian artery, the brachial plexus may be involved, and, in case of injury to the common carotid, the pneumogastric.

The diagnosis of an injury to the vertebral artery is very difficult on account of its deep location and its frequent abnormal course. This explains the unfavourable prognosis. As was said above, the artery passes through the vertebral foramina of the six upper cervical vertebræ (see Fig. 276). Before its entrance into the foramen of the sixth cervical vertebra the artery lies for a distance of from five to eight centimetres between the clavicle and the transverse process of the sixth cervical vertebra beside the common carotid, and its injury can therefore easily be mistaken for that of the common carotid. Hæmorrhage from the common carotid and the vertebral may be arrested by compression below the sixth cervical vertebra. If one applies compression above the so-called carotid tubercle—that is, the transverse process of the sixth cervical vertebra, which lies somewhat below the upper border of the thyroid cartilage—one strikes the common carotid alone, and if the hæmorrhage stops, the common carotid is injured, and if it does not stop, the vertebral is injured, provided that the latter really enters the vertebral foramen of the transverse process of the sixth cervical vertebra. To exclude more surely simultaneous compression of the vertebral, Kocher recommends compression of the common carotid, not against the spinal column, but by grasping the sterno-mastoid muscle between the fingers.

The treatment of injuries to the arteries of the neck must be prompt and energetic. Death unfortunately often occurs from hæmorrhage, especially after an incised or gunshot wound of the common carotid or subclavian, before medical assistance is at hand.

The simplest and first means of arresting the hæmorrhage is, of course, compression of the wound with the finger (digital compression), or, if that is impossible, digital compression of the afferent trunk at a point proximal to the injury by pressing, in case of hæmorrhage from the external or internal carotid, for example, the common carotid firmly against the vertebral column with the thumb, and encircling the back of the neck with the fingers.

Bertrand saved a patient in a desperate case of punctured wound of the external carotid artery by means of digital compression which was continued for seventy-two hours.

In case of hæmorrhage from the subclavian compression is made use of, or the wound is packed with iodoform gauze or with other aseptic material which may chance to be at hand, and a temporary dressing applied so as to exert pressure. Hæmorrhage from the subclavian has been permanently arrested by these means.

The best and surest method of arresting the hæmorrhage in injuries to the arteries is double ligation of the artery in the wound above and

below the point of injury. Proximal ligation alone is usually insufficient, as secondary hæmorrhage then takes place after the establishment of the collateral circulation. Death formerly occurred frequently in consequence of this. The best course is to compress the trunk of the injured artery below the wound, enlarge the latter if necessary, find the injured vessel in the wound and ligate it with aseptic catgut or silk proximally and distally from the point where it was wounded. The injured portion of the vessel can then be divided or excised between the ligatures. It is important that any branches that leave the artery near the place of the injury should likewise be ligated.

If proximal and distal ligation of the injured artery in the wound is impossible, and hæmorrhage can not be stopped by compressing or by packing the wound, ligation of the afferent main trunk should be undertaken proximally from the wounded point at the so-called place of election. This method is especially applicable to the common carotid in case of hæmorrhage from branches which are not accessible to direct ligation, as in case of injury to the internal maxillary, or the deep temporal arteries, the prognosis of which is very unfavourable. One must, however, always be prepared for secondary hæmorrhages after this very uncertain ligation of the injured artery proximally from the wound.

In case of hæmorrhage from the external carotid or its branches, the easier ligation of the common carotid has been recommended, because the trunk of the former is too short, and the operation is difficult on account of the surrounding veins and nerves.

Guyon and Madelung, however, have shown, in refutation of the supposed disadvantages that have been quoted, that in case of hæmorrhage from the external carotid this artery and not the common carotid should be ligated. It may also be found necessary to ligate the separate branches of the external carotid. Ligation of the external carotid has the great advantage over that of the common carotid that after the former the brain circulation remains intact, and, accordingly, no cerebral symptoms develop. In forty-one per cent of the cases of ligation of the common carotid artery brain symptoms appeared. According to Pilz, of sixty cases of ligation of the external carotid, only seven had a fatal result, while of two hundred and twenty-eight cases of ligation of the common carotid, one hundred and twenty-three ended fatally.

Ligation of the bleeding artery in the wound is, to be sure, often impossible, and one must content himself with compression or ligation in continuity at the place of election. For the technique of ligation of the different vessels in the neck, see § 90.

Wounds of the Large Veins of the Neck are likewise very dangerous, partly from hæmorrhage, partly from the entrance of air. If an incised or gunshot wound of a large vein, the internal jugular for instance, has taken place, and there is an open, gaping wound, a continuous stream of dark blood gushes forth—so great in amount that death may very quickly ensue if the hæmorrhage is not stopped by digital compression of the wound. Wounds of the internal jugular vein are just as dangerous as those of the common carotid, and spontaneous arrest of the hæmorrhage is not to be expected. Death has ensued in every case, according to G. Fischer, in which surgical aid was not at hand. Still more serious are, naturally, injuries to the subclavian and innominate veins. In case of injury to the large veins of the neck from puncture, with impeded escape of the blood, such very large subcutaneous hæmatomata may be formed that death from suffocation ensues in consequence of pressure upon the trachea. Suppuration, sepsis, or pyæmia are also to be feared from subsequent infection of the hæmatoma.

As regards the danger of the entrance of air through a wound in a vein, it is well known that this is greatest in the case of the veins in the neck and in the neighbourhood of the heart, because the venous blood is here aspirated with increased rapidity in consequence of the negative intrathoracic pressure during inspiration. If a vein in the neck or any large vein near the thorax is opened, and if its walls cannot collapse in consequence of its connection with its surroundings—e. g., with fascia, as in the case of the internal jugular, or with the clavicle, as in the case of the subclavian—air is usually aspirated with a peculiar sucking sound. Single bubbles of air do no harm, as they are absorbed by the blood. If, however, a large amount of air is aspirated, death may ensue in a few moments. Death from entrance of air into the veins has been explained in various ways. I consider the assumption correct that the air collects in the right side of the heart and prevents the contractions of the right ventricle, so that the heart finally stops in diastole (Conty). The air filling the right side of the heart prevents the influx of venous blood, and hence the circulation in the lungs is first suspended, and finally the circulation of the whole body. Others maintain that the air passes from the heart into the pulmonary arteries and remains there, interrupting the circulation in the lungs and preventing also the filling of the left ventricle with fresh blood. Death has also been observed in consequence of air emboli in the brain (see also Principles of Surgery, page 60).

In operations in the vicinity of the heart or the thorax, including the neck and axilla, one should be fully alive to the danger of the entrance of air into veins of any size that are opened, especially the

internal jugular and the subclavian. On account of this danger, French surgeons have called this part of the body the *région dangereuse.* Air is particularly likely to be aspirated in large quantities if the patient makes deep inspiratory movements when one of the larger veins of the neck has been opened. Death from this cause has been observed even after venesection at the elbow, and after injury to a sinus of the dura.

In opening veins which are situated more peripherally—in the forearm for instance, or the lower extremities—aspiration of air is not to be feared. Forcible injection of air is of course to be distinguished from aspiration of air. Death has occurred from injection of air into the veins of the uterus, for instance.

The treatment of wounds in the veins of the neck conforms essentially to the same principles that apply to injuries of the arteries. Here also hæmorrhage should be temporarily stopped by digital compression of the wound, and the entrance of air must be prevented. Final arrest of the hæmorrhage is secured here also by ligation of the vein in the wound. When a large vein is wounded it should be ligated above and below the point of injury, just as in wounds of arteries, as otherwise secondary hæmorrhage from the unligated proximal end of the vein may occur. In case a large vein of the neck is completely divided, both ends should therefore, as a rule, be ligated.

If the application of a ligature is difficult, or proves impossible, the attempt should be made to arrest the hæmorrhage by packing the wound with sterilized gauze and applying a bandage that exerts pressure. Here also, in exceptionally difficult cases, continued digital compression may be employed.

There is little that can be done in case of entrance of air into large veins. It is advisable, by way of prophylaxis, to proceed with all possible caution in operations near the thorax, and especially on the neck and in the region of the subclavian and innominate veins. If a large vein has been injured and air aspirated, the opening in the vein should be closed at once with the finger, especially during inspiration, and the wound filled with a 1-in-1,000 bichloride solution or a three-per-cent solution of carbolic acid. Too vigorous sponging of the wound is to be avoided in operations upon the neck and in connection with venous injuries in general in the neighbourhood of the heart, as aspiration of air is favoured in dry wounds. The air bubbles sometimes come out again through the wound during expiration, for which reason H. Fischer has properly recommended the inducement of energetic movements of expiration by compression of the thorax. The vein is then to be tied as quickly as possible, proximally and distally, from the

point of injury, to prevent the entrance of more air. If a large amount of air has been aspirated and has already reached the right side of the heart, no treatment is of any avail. Death generally results instantly in such cases. Aspiration of the air from the heart is not possible.

§ 90. **Ligation of the Arteries of the Neck (Innominate, Subclavian, Common, External, and Internal Carotids, Superior and Inferior Thyroids, Lingual, Vertebral).**—The operation of ligation of the arteries of the neck is performed aseptically by dividing the overlying soft parts or enlarging an already existing wound, exposing and isolating the artery, and tying an aseptic ligature of silk or catgut firmly about the latter. The field of operation is carefully cleansed with soap beforehand, shaved, rubbed with ether, and disinfected with a 1-in-1,000 bichloride solution or a three-per-cent solution of carbolic acid. After dividing the skin and the fascia, one dissects down to the artery with a scalpel, aided by the finger, a grooved director, or the handle of a knife. When the sheath of the artery has been exposed it is carefully raised with mouse-toothed thumb-forceps from the artery itself and opened by means of a superficial incision with a knife, curved scissors, or better, with a probe. After isolating the artery on all sides from its sheath, an aseptic silk or catgut thread is passed around the vessel by means of an aneurism needle and then firmly tied, usually in the larger arteries, with two double or surgical knots, and then with a simple knot in addition. In tying a surgical knot the ends of the thread are passed around each other twice instead of once, as in the ordinary simple knot. When arteries are injured, by puncture for example, the vessels are always ligated, as has been said, twice proximally and distally from the puncture, to avoid secondary hæmorrhage from the wound in the vessel; and then the injured portion may be excised or simply divided. Any branches that leave the trunk at the place of the injury must also be ligated if secondary hæmorrhages are to be surely avoided.

In case of complete division of an artery, both ends are clamped and tied.

The wound made by the operation is then finally drained in its deepest part, closed by suture, and covered with an aseptic protective dressing, which includes the head, the neck, and the thorax. Wounds which have already become infected, or contused wounds, should be packed with iodoform gauze.

Ligation of the veins in continuity is performed in essentially the same way as has been described for the arteries.

Any vessel of the neck that is to be ligated should be isolated as completely as possible—that is, the inclusion of surrounding tissue, particularly the nerves, should always be avoided.

1. **Ligation of the Innominate Artery.**—*Topography.*—The innominate, twenty millimetres long and thirteen to fourteen millimetres in diameter, lies behind the manubrium sterni on the trachea and is partly covered by the innominate vein. The pneumogastric nerve runs down on the outer side of the artery into the posterior mediastinum. The point of bifurcation of the artery into the right subclavian and common carotid lies at the apex of the pleura behind the manubrium sterni near the sterno-clavicular articulation. Of eighteen cases of ligation of the artery given in literature, nearly all of which were for aneurism at the point of bifurcation of the artery, only one (by Smith, New Orleans, 1864) terminated successfully.

In most cases the right subclavian and common carotid were first looked for at their point of origin, and from here one passed down into the anterior mediastinum, where the innominate was found. The method of incision is very varied.

Technique of the Operation.—The head is bent well backward and turned a little to one side. The skin incision used by Langenbeck (see Fig. 277) begins about five centimetres above the origin of the right sterno-mastoid, runs downward along its inner border as far as the edge of the manubrium sterni, here forms a curve, and continues upward some centimetres farther along the median border of the left sterno-mastoid. The platysma and the upper cervical fascia are divided along the course of this incision, and one then works his way with the finger and handle of the scalpel between the sterno-mastoid and the sterno-hyoid muscles. The latter muscle and the sterno-thyroid should, if necessary, be divided on the right side or on the left as well. The right sternal portion of the sterno-mastoid can usually be left intact. The common carotid is now exposed by drawing the internal jugular vein and the pneumogastric nerve cautiously outward away from the artery with a blunt retractor. The pneumogastric nerve lies behind the internal jugular vein and to the outer side of the common carotid. If the common carotid is now followed downward, one comes to the right subclavian. This is likewise exposed, the pneumogastric, the recurrent

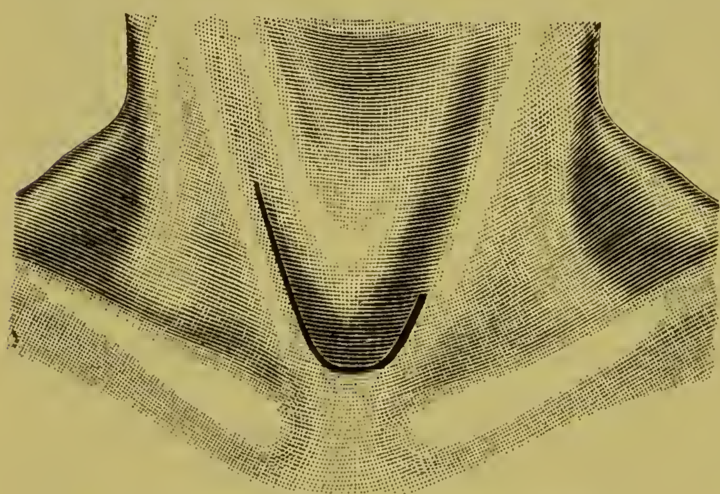


Fig. 277.—Incision for ligation of the innominate artery.

laryngeal, and the phrenic nerves being carefully protected. One then follows the subclavian toward its source and easily finds the innominate. The right pneumogastric lies anterior to the beginning of the subclavian; the recurrent laryngeal, which here leaves the pneumogastric, passes behind the subclavian in the form of a sling; and finally the phrenic nerve runs between the subclavian artery and the innominate vein into the thorax. An aneurism needle threaded with aseptic silk is then passed from below upward around the isolated innominate artery, the pleura being avoided. The ligature is applied about one and a half centimetres below the bifurcation, and the silk must be tightened very gradually, for fear of a too sudden stoppage of the circulation.

Mott, who first ligated the innominate artery in 1818, recommended a flap incision. It begins in the middle of the interclavicular notch of the sternum and then runs outward for about nine centimetres along the upper border of the clavicle. A second incision of the same length along the inner border of the sterno-mastoid muscle meets the beginning of the first incision on the upper border of the sternum. The flap of skin thus marked out is raised from below upward, the platysma, the origin of the sternal portion of the sterno-mastoid, and the sterno-hyoid and sterno-thyroid muscles are divided, and then the same course is taken as above. This method of Mott affords, no doubt, the greatest access to the artery.

Bardenheuer has proposed the direct exposure of the innominate artery by resection of the overlying bone. He makes an incision along the upper border of the manubrium sterni, and a second one perpendicular to this down the middle of the sternum, and resects subperiosteally the manubrium sterni together with the ends of the first ribs and the clavicle.

The collateral circulation, after tying the innominate, takes place through the left common carotid and vertebral, and the peripheral branches of the right common carotid and vertebral. Smith was compelled to ligate the vertebral artery later on, on account of secondary hæmorrhage. To prevent this, one could ligate the vertebral artery at the same time with the innominate.

2. **Ligation of the Subclavian Artery.**—*Topography.*—The subclavian originates on the right side from the innominate artery, on the left from the arch of the aorta, and runs then in the form of a curve between the scalenus anticus and medius, over the first rib, behind the clavicle to the axilla. On its outer side, and somewhat behind it, lies the brachial plexus. The subclavian vein lies in front of and to the inner side of the artery. Before passing between the scaleni, the artery is covered by the lower end of the internal jugular vein. The pneumogastric nerve lies here between the two vessels, and on the right side, behind the artery, lies the recurrent laryngeal nerve.

The situation of the external jugular vein is of special importance in connection with ligation of the subclavian. It runs downward behind the outer border of the sterno-mastoid muscle and empties in front of the scalenus anticus into the subclavian vein. In ligating the subclavian artery above the clavicle, one should always look for the external jugular vein and divide it between two ligatures, so as to avoid all danger of accidental entrance of air. The same is true of the suprascapular vein, which likewise crosses in front of the scalenus anticus above the clavicle. The thoracic duct lies on the left side between the subclavian artery and the œsophagus, and, coming from above, empties in the angle between the internal jugular and subclavian veins.

Ligation of the subclavian is performed either above or below the clavicle (Fig. 278, 1, 2).

Ligation of the subclavian above the clavicle is performed by bending the head toward the opposite side and lowering the clavicle by drawing the arm downward and inward so as to increase the amount of space. A sand bag is laid under the shoulders.

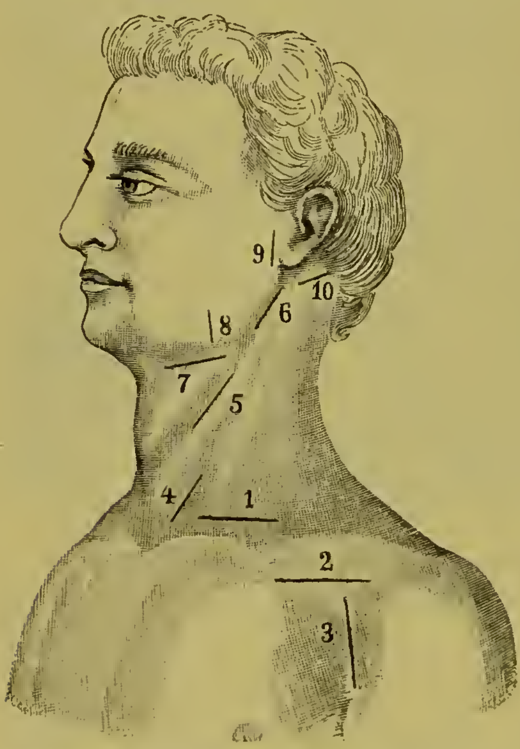


FIG. 278.—Incision for ligation of the subclavian, common carotid and their branches: *1*, *2*, ligation of the subclavian; *3*, of the axillary; *4* and *5*, of the common carotid; *6*, of the external carotid; *7*, of the lingual; *8*, of the facial; *9*, of the superficial temporal; *10*, of the occipital.

The horizontal incision in the skin (see Fig. 278, 1) begins near the outer edge of the sterno-mastoid muscle a finger's breadth above the clavicle and runs parallel to the clavicle for about nine or ten centimetres to a point near the anterior border of the trapezius. After division of the skin and platysma, the external jugular vein is looked for at the outer edge of the sterno-mastoid muscle, tied in two places, and cut. After dividing the deep fascia and pushing the omohyoid muscle outward, one feels for the tubercle of the first rib, on which is inserted the scalenus anticus muscle. The artery lies to the outer side of this tubercle. The tubercle is easily found if one remembers that the lowest part of the posterior edge of the sterno-mastoid lies in the same line with the outer edge of the scalenus. The brachial plexus, which comes in sight after dividing the deep fascia, and the scalenus anticus itself, may also serve

as guides. From the tubercle the finger is passed in an outward direction, in doing which one must not keep too close to the clavicle, and the subclavian artery is found between the insertion of the scalenus anticus and the brachial plexus. The suprascapular vein, which crosses the field of operation and often causes trouble, is, if necessary, divided between two ligatures. The subclavian vein, which lies in front of the scalenus anticus, is not seen at all. If the sterno-mastoid muscle is drawn well inward by means of a retractor, and the clavicle drawn downward in the manner described above, the ligature can easily be applied with an aneurism needle, which should be passed from without inward.

In case of the more difficult and therefore less frequent ligation of the subclavian below the clavicle on the anterior thoracic wall, it must be remembered that the artery lies much deeper here in the so-called Mohrenheim's space than above the clavicle. The skin incision runs along for about ten centimetres parallel to the outer half of the clavicle, about a finger's breadth below it, as far as the coracoid process (see Fig. 278, 2). In dividing the skin and the superficial fascia, one should be careful to avoid the cephalic vein, which lies farther outward. The outer edge of the pectoralis major is incised transversely as far as circumstances may require. After dividing the costo-coracoid membrane, one passes bluntly in with the finger into Mohrenheim's space between the deltoid, the subclavius, and the pectoralis major, and here finds the artery to the inner side of the brachial plexus, and partly covered by the vein. The latter is pushed inward, the former upward and outward, and the aneurism needle is passed from the inner side around the isolated artery.

Secondary hæmorrhages frequently follow ligation of the subclavian, resulting, no doubt, from the high pressure in the artery. The mortality amounts to 47·2 per cent. The operation must be conducted under strict aseptic rules, to avoid the possibility of empyema, etc., in consequence of suppuration.

Incision 3 in Fig. 278 has reference to the ligation of the axillary artery. It is especially adapted to the prevention of hæmorrhage in connection with disarticulation at the shoulder (see Surgery of the Shoulder).

3. **Ligation of the Common Carotid.**—*Topography.*—The common carotid arises on the right side from the innominate, on the left from the arch of the aorta. The artery runs about in the direction of the sterno-mastoid muscle from the sterno-clavicular articulation upward. At its lower part it lies between the two heads of the sterno-mastoid, and then approaches the inner border of the same. The artery lies beneath the deep cervical fascia, which

here forms the sheath of the vessel, and to the inner side of the internal jugular vein, which partly covers the artery. The pneumogastric nerve lies between the two, a little posteriorly but immediately adjacent. Behind the sheath lies the sympathetic nerve. At the level of the larynx is found the descending branch of the hypoglossal nerve on the anterior surface of the artery, and to the outer side lies the so-called carotid tubercle—that is, the transverse process of the sixth cervical vertebra.

On a level with the upper border of the thyroid cartilage the artery divides into the external and internal carotids (see Fig. 279). It gives off no branches.

One of the abnormalities in the origin of the common carotid is especially important. This is when the left common carotid arises from the innominate and runs obliquely upward in front of or behind the trachea.

Ligation of the common carotid is most frequently and most easily performed on a level with the larynx at the inner border of the sterno-mastoid muscle. The incision through the skin, about six or eight centimetres in length, begins at the inner edge of the sterno-mastoid on a level with the upper border of the thyroid cartilage. The transverse process of the sixth cervical vertebra, or the crico-thyroid membrane, which lies on the same level, should form the middle point of the incision. After cutting through the skin and the platysma, carefully avoiding the veins, particularly the external jugular in the upper part of the incision, and after dividing the superficial fascia, the inner border of the sterno-mastoid is exposed. On a level with the transverse process of the sixth cervical vertebra, which can easily be felt, the sterno-mastoid and the other soft parts are retracted outward, and the inner border of the wound is drawn toward the median line. The sheath of the vessel, which now presents itself, is carefully opened after the omohyoid muscle which crosses it has been drawn downward. The artery must now be carefully isolated from the vein which lies to its outer side. Lying upon the artery is the descending branch of the hypoglossal nerve, and behind it, between

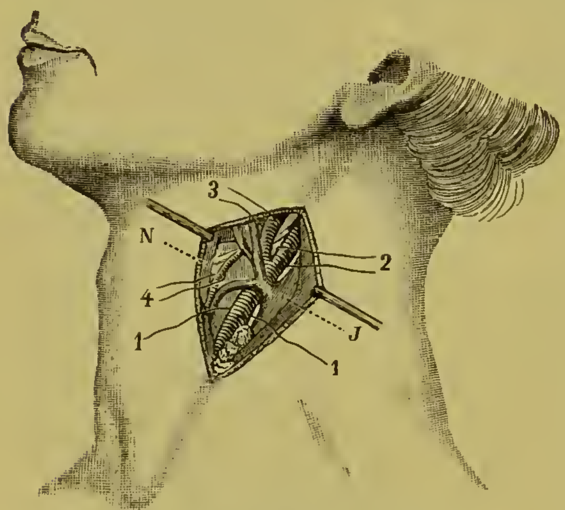


Fig. 279.—Bifurcation of the common carotid: the overlying soft parts, including the skin, platysma, sterno-mastoid, etc., are retracted to one side; *1*, ligature for tying the common carotid; *2*, for the internal carotid; *3*, for the external carotid; and *4*, for the superior thyroid; *J*, internal jugular vein; *N*, superior laryngeal nerve; the pneumogastric nerve is visible between the common carotid and internal jugular.

the artery and the vein, is the pneumogastric. Separation of the artery from the pneumogastric must be done as cautiously as possible. The aneurism needle should be carried around the artery from without inward. The ligature should be applied on a level with the carotid tubercle.

Ligation of the common carotid above the clavicle is much more difficult, owing to the deep position of the artery, to the fact that it is covered by the vein, and to the proximity of the thoracic duct on the left side. Of the different methods, Zang's is most strongly to be recommended. By this method the artery is looked for between the two points of origin of the sterno-mastoid muscle.

The incision through the skin, about six or eight centimetres long (Fig. 278, 4), between the two heads of the sterno-mastoid muscle, extends to the clavicle. After dividing the platysma, the two heads of the sterno-mastoid are bluntly separated until the internal jugular vein becomes visible. The vein with the clavicular portion of the sterno-mastoid is retracted gently outward and the sternal portion, together with the sterno-hyoid and sterno-thyroid muscles, is drawn inward. On the inner side of the vein is found the pneumogastric. The artery lies still farther inward and deeper.

Statistics of Ligation of the Common Carotid.—Albertin collected the statistical figures of Lefort covering 411 observations, and of Wyeth covering nearly 800 observations. Secondary cerebral disturbance (thrombosis, embolism, softening of the brain) is the greatest danger attending ligation of the common carotid. Of 320 cases, 170 ended in recovery and 132 proved fatal. Of these 132 deaths, 78 were caused by cerebral affections alone. The brain symptoms are syncope, coma, delirium, convulsions, headache on the same side, hemiplegia on the opposite side, aphonia, dysphagia, dyspnœa, etc. The brain was affected in 100 cases. Ligation of both common carotids had been performed twenty-three times (once at a single sitting). There were eighteen recoveries and only five deaths. W. Zimmermann, from a collection of 65 cases of ligation of the common carotid, finds 68·1 per cent of recoveries and thirty-one per cent of deaths. Twenty-six per cent of these patients showed brain symptoms and 11·6 per cent had softening of the brain.

According to Pilz, the mortality attending ligation of the common carotid is eighteen per cent; according to Friedländer, thirteen per cent. Pilz found that cerebral lesions resulted in thirty-two per cent of the cases. In more than half the cases the common carotid is tied at the present time where ligation of the external carotid would suffice. Ligation of the external carotid is practically never followed by bad results. Among one hundred and thirty cases of ligation of the external carotid collected by Lipps, only two resulted fatally from cerebral embolism. One should therefore tie the external carotid whenever possible, in place of the common carotid. Ligation of the latter should come under consideration only in conditions that

are dangerous to life—such as hæmorrhage, etc.—which can not be remedied by ligation of the external carotid. When necessary, the external carotid should be tied on both sides.

4. **Ligation of the External and Internal Carotids.**—The division of the common carotid into its two branches, the external and internal carotid, takes place, as was said above, at the level of the upper border of the thyroid cartilage (see Fig. 279). The external carotid lies to the median (Fig. 279, 3) and the internal carotid to the outer side (Fig. 279, 2). The external carotid can also be recognised from the fact that at a slight distance from its origin it gives off the superior thyroid. The arteries are covered by the temporo-maxillary vein.

The best method of ligating the external and internal carotids is to expose the upper part of the common carotid and then follow it to the point where it divides. This is done by means of an incision downward from near the angle of the jaw, along the inner border of the sterno-mastoid muscle. The sheath of the branch which one wishes to ligate is then opened. The trunk of the external carotid is only from one to one and a half centimetres long. The rule is always to tie the external carotid between the origin of the thyroid and the lingual arteries. Wyeth says that after ligation of the external carotid the superior thyroid should always be tied as well.

The external carotid divides, as is known, at about the level of the lobule of the ear into its two terminal branches, the temporal and internal maxillary. The external carotid can here be ligated between the posterior border of the jaw and the inner edge of the sterno-mastoid muscle by means of an incision parallel to the former (see Fig. 278, 6). Instead of the short trunk, the single branches of the external carotid may be tied.

After ligation of the internal carotid the collateral circulation is mainly restored by the circle of Willis and the ophthalmic artery. Gluck has proposed ligation of the internal carotid in the carotid canal after partial resection of the petrous portion of the temporal bone with the chisel—e. g., for aneurism.

5. For a description of ligation of the lingual (Fig. 278, 7), the facial (Fig. 278, 8), the superficial temporal (Fig. 278, 9), and the occipital arteries (Fig. 278, 10), see pages 204 and 396.

6. **Ligation of the Superior Thyroid Artery** (Fig. 279, 4).—As was said above, the superior thyroid arises from the external carotid just above the point of division of the common carotid on a level with the upper border of the thyroid cartilage. It first ascends, then curves downward and enters the upper border of the lateral lobe of the thyroid gland in which it runs toward the isthmus.

In ligating the superior thyroid, an incision is made downward from near the angle of the jaw and parallel to the inner border of the sterno-mastoid muscle. After division of the skin, the platysma, and the superficial fascia, the artery is found about one to one and a half centimetres above the omohyoid muscle in the triangle formed by the latter muscle, the posterior belly of the diagastric, and the sterno-mastoid. The common carotid, the internal jugular vein, and the sterno-mastoid muscle must first be drawn outward. If one wishes to ligate both the superior and inferior thyroid arteries—e. g., in a case of goître—the incision is made along the *outer* border of the sterno-mastoid (see page 584).

7. **Ligation of the Inferior Thyroid Artery.**—The inferior thyroid, which arises from the thyroid axis of the subclavian, lies in the vicinity of the fifth to the seventh cervical vertebræ and crosses the œsophagus transversely. The cervical plexus of the sympathetic descends in front of the artery, and the recurrent laryngeal nerve crosses the artery at the point where it divides into an ascending and descending branch (see Figs. 289 and 290, pages 564 and 565). Injury or inclusion of the recurrent laryngeal nerve is most surely avoided by ligating the artery proximally to this point of bifurcation. Regarding the various methods of ligating the inferior thyroid artery, the reader is referred to pages 584, 585.

8. **Ligation of the Vertebral Artery.**—The topography of this artery has already been given (see page 512).

Ligation of the artery is performed at its lower portion before it enters the vertebral foramen of the transverse process of the sixth cervical vertebra. The skin incision is best made in this case along the outer border of the sterno-mastoid near the sixth cervical vertebra, extending obliquely downward. It is not so advisable to go in at the inner border of the muscle, as one strikes the artery too near its point of origin from the subclavian.

The skin, platysma, and superficial fascia are divided along the outer border of the sterno-mastoid muscle, the external jugular vein being guarded in the upper corner of the wound, or tied in two places and divided. The unopened sheath of the common carotid and the sterno-mastoid are drawn inward. With the head of the patient held in a straight line and inclined slightly forward, the tubercle of the transverse process of the sixth cervical vertebra is felt for, and in a median direction from this lies the artery, in the muscular interspace between the scalenus anticus and the longus colli, upon the cervical vertebræ. The vein lies to the outer side of the artery. The muscles named are drawn aside and an aneurism needle with a small curve is passed around the artery from the outer side.

W. Alexander has recommended unilateral or bilateral ligation of the vertebral artery for the eure of epilepsy. The results in the twenty-one eases that Alexander has treated in this way seem to be favourable. According to Baraez, unilateral or bilateral ligation of the vertebral artery has been performed for epilepsy forty-five times. Eight cases were permanently eured, in eleven eases there was improvement, in nineteen eases nothing was gained, and the result in seven cases is unknown. Fresh cases of epilepsy are best suited for this treatment. It is not adapted to Jaeksonian epilepsy. Trephining is here indicated. It is not clear as yet why ligation of this artery should have a eurative effect upon epilepsy. Perhaps the unintentional but frequent injury to the sympathetie has something to do with it.

§ 91. **Nerve Injuries and Nerve Operations upon the Neck.**—We mention first injuries of the cervieal or braehial plexus. These are either eontusions from a kiek or blow with or without fraeture of the elaviele, or partial or eomplete division or laeeration from gunshot, stab, or punctured wounds, espeeially near the outer border of the sterno-mastoid muscle. Corresponding symptoms of paralysis follow aeeording to the degree and the extent of the injury, amounting sometimes to eomplete paralysis of the arm that is involved. Partial and temporary paralysis is eaused partieularly by puncture wounds, eontusions, and by eompression of the plexus in consequenee of an extravasation of blood, foreign bodies, ete. There is, as a rule, very severe pain. After milder injuries—e. g., after eontusion of the nerve plexus—symptoms of irritation are often notieed in the form of eonvulsive movements, hyperæsthesia, and neuralgia.

Motor paralysis of the arm may be complete, while the paralysis of sensation is only partial, in ease intaet collateral nerve traets eonvey the sensory impulses.

Indireet paralysis sometimes oceurs in the region supplied by the uninjured brachial plexus, in ease, for example, a traumatie neuritis in a neighbouring nerve anastomosing with the plexus involves it seeondarily. All paralyses resulting from an injury show themselves immediately after the reception of the traumatism. Later paralysis, oceurring secondarily, is caused, as a rule, by degenerative processes, by eompression from the callus after fraeture of the claviele, a rib, or vertebra, by eieatrieial eontraetion, or the presenee of a foreign body—e. g., a ball that has healed in. In sueh eases the paralytie symptoms steadily inerease in eorrespondence with the gradually increasing compression.

As a result of long-eontinued paralysis after injury to the nerves, the well-known trophic disturbances of the skin and the muscles appear, as briefly described in Prineiples of Surgery, page 456 ff.

The prognosis of traumatic paralysis depends upon the degree of the injury; and yet, even after complete paralysis of the arm, in consequence, for example, of a gunshot injury to the brachial plexus, more or less complete recovery has been observed. The prognosis of paralysis from compression is, generally speaking, favourable. The paralysis has been seen to disappear immediately upon the removal of the callus or foreign body that presses upon the nerve.

The treatment of traumatic paralysis of the brachial plexus is in accordance with the principles which are given in detail in Principles of Surgery, § 88. The plexus should be exposed at the proper point, and the further steps will depend upon the condition of things that is found, suture of the divided plexus being performed if necessary (see Principles of Surgery, page 469), a foreign body or callus removed, etc. With reference to the treatment of defects in nerves, see Principles of Surgery, page 470.

Stretching the Cervical or Brachial Plexus.—In case of symptoms of irritation (convulsive movements, neuralgia), aside from massage, stretching the cervical or brachial plexus after Nussbaum is indicated, and satisfactory results have thus been attained. In stretching the plexus, the patient is placed in such a way that the shoulder on that side is pressed downward and the head bent toward the opposite side. A longitudinal incision is then made (from six to eight centimetres in length) along the anterior border of the lower portion of the trapezius muscle, extending to about three fingers' breadth above the clavicle. After dividing the skin, platysma, and fascia, one passes in above the omohyoid muscle and the transverse cervical artery, between the sterno-mastoid and the scalenus anticus on one side and the trapezius on the other, and then, after division of the deep cervical fascia one comes directly upon the plexus. After blunt isolation of the plexus it is lifted out with an aneurism needle, the nerve sheath is opened, and the nerves stretched in both directions by use of the thumb and forefinger.

The cervical plexus is found higher up, being best reached by a longitudinal incision along the posterior border of the sterno-mastoid muscle. The incision through the skin, which is about six centimetres long, begins about three fingers' breadth below the mastoid process.

The after-treatment consists in massage, active and passive movements, and the application of electricity.

Of other injuries to the nerves of the neck, those of the pneumogastric, the recurrent laryngeal, the phrenic, the sympathetic, the hypoglossal, and the spinal accessory are of special importance.

Wounds of the Pneumogastric.—The pneumogastric is especially subject to injury in connection with the extirpation of tumours of the

neck. In ligation of the common carotid artery the nerve, which lies between the artery and the internal jugular vein, may be included in the ligature in case of insufficient isolation of the artery. The recurrent laryngeal may be included in the same way in ligation of the inferior thyroid artery or injured in the extirpation of a goître (see Figs. 289 and 290, pages 564, 565).

After division of the pneumogastric on one side, pulse and respiration usually remain unchanged. After one-sided division of the recurrent laryngeal, however, there ensues paralysis of one of the muscles that open the glottis. The voice is rough and hoarse, or the patient is aphonic (see Diseases of the Larynx, § 105). If the pneumogastric is divided above the point of origin of the superior laryngeal, the latter is also paralyzed. In man the superior laryngeal appears not to innervate the muscles of the vocal cords as it does in many animals, but probably the muscles of the epiglottis (Gerhardt). After division of the pneumogastric on one side, pneumonia and dysphagia have sometimes been observed. Stimulation of the pneumogastric causes slowing of the pulse. Schou recommends immediate tracheotomy in case of division of the pneumogastric or the recurrent laryngeal, and then tamponing the trachea to prevent aspiration pneumonia. This advice is, in my opinion, wholly wrong. Widener, who has collected nineteen cases of division of the pneumogastric—occurring, for example, during the removal of tumours from the neck—also regards tracheotomy as not only unnecessary but even dangerous, because it imperils the aseptic course of the wound-healing. Widener found that in unilateral division of the nerve there were no bad after-effects on the part of the lungs, the pulse, the digestive organs, and the whole organism.

If both pneumogastrics or recurrent laryngeals are injured or divided, death ensues in consequence of paralysis of the muscles that open the glottis and from heart and lung disturbances (acceleration of the pulse [tachycardia], pneumonia, œdema of the lungs). Abnormal acceleration of the heart is, next to paralysis of the vocal cords, the most frequent symptom of paralysis of the pneumogastric. The lung symptoms (slowing and acceleration of respiration, dyspnœa, pneumonia, aspiration pneumonia, œdema of the lungs) are variable, being influenced in part by the paralysis of the vocal cords and the cardiac disturbances. So-called cardiac asthma (Riegel, Tuczek, Kredel) is caused by irritation of the terminal fibres of the pneumogastric in the lungs and paralysis of those in the heart. It is characterized by marked acute inflation of the lungs, a very much accelerated pulse, in some cases also by dyspnœa, with rapid respiration, and cyanosis.

The hypoglossal nerve is especially subject to injury from wounds

in the submaxillary region—from attempts at suicide, for instance. The result of injury to one or both nerves is motor paralysis of the tongue on one or both sides.

Injuries to the phrenic nerve always lead to paralysis of the corresponding half of the diaphragm, which is usually only to be recognised, however, by careful examination, as active respiratory movements with the muscles of the thorax are not interfered with, and such patients can therefore take deep inspirations (Gowers). In case of complete paralysis of the phrenic nerves on both sides, death results immediately from paralysis of respiration, as has been experimentally demonstrated upon animals. Irritation of the phrenic nerve causes continuous coughing and hiccoughing in consequence of contraction of the diaphragm.

Isolated injuries of the sympathetic nerve have been observed in wounds of the neck, especially gunshot wounds behind the angle of the lower jaw and above the clavicle. Seeligmüller has collected thirteen cases of traumatic paralysis of the cervical sympathetic. The most constant symptoms of paralysis of the cervical sympathetic are contraction of the pupil and the palpebral fissure, trophic and vasomotor disturbances—e. g., hyperæmia of the involved half of the face, conjunctivitis, flow of tears, diminution in the size of the eyeball, myopia, etc. Irritation of the sympathetic nerve causes the pupil on that side to dilate, and this symptom is present, according to Seeligmüller, in almost all fractures of the clavicle. Irritation of the sympathetic appears also by itself to occasion acceleration of the heart (tachycardia), which is likewise observed after paralysis of the pneumogastric. In case of paralysis of the part of the sympathetic that goes to the cardiac plexus, there ensues a slowing of the heart (see page 565, Fig. 290).

Paralysis of the spinal accessory nerve brings with it paralysis of the two muscles of the neck that it supplies—viz., the sterno-mastoid and the trapezius—which, however, are also supplied by two branches of the cervical plexus. Its anterior or inner branch, which unites with the pneumogastric, supplies as recurrent laryngeal the muscles of the larynx, with the exception of the crico-thyroid, which is supplied by the superior laryngeal and also a part of the velum palati and the pharyngeal muscles (see § 101). From paralysis of the spinal accessory—or, in other words, the sterno-mastoid and trapezius muscles, paralytic torticollis results, and irritation of the same nerve causes spasm of the muscles named (spastic torticollis, see page 502 ff.).

The operation for stretching or dividing the spinal accessory nerve in an otherwise incurable case of spastic torticollis, for instance, may be performed by an incision five or six centimetres in length along the

anterior border of the sterno-mastoid muscle from the mastoid process to about the level of the angle of the jaw (Fig. 280 *a*). After dividing the fascia and retracting the edges of the wound, the nerve is found beneath the deeper fascia, directly below the transverse process of the atlas, which can be felt in the upper angle of the wound and which is covered by the digastric muscle. Alongside the spinal accessory nerve there is usually found a small branch of the second cervical nerve. Another very good plan is to look for the nerve at the posterior border of the sterno-mastoid muscle at the boundary between the upper and middle thirds by making here an incision about five or six centimetres long which begins a finger's breadth below the mastoid process. The nerve lies here very superficially, and the skin and fascia must therefore be divided cautiously. The posterior border of the sterno-mastoid is then laid bare in the upper angle of the wound, and if it is followed downward one soon comes upon the nerve, which runs obliquely and passes around the posterior border of the sterno-mastoid muscle. Mosetig-Moorhof stretched both accessory nerves in a case of spastic torticollis with good results. Cures have also been observed after neurectomy. It would be better, perhaps, to combine the two methods—that is, after stretching, to perform neurectomy immediately. Schwartz likewise recommends stretching the nerve and then resecting a piece about two centimetres long.

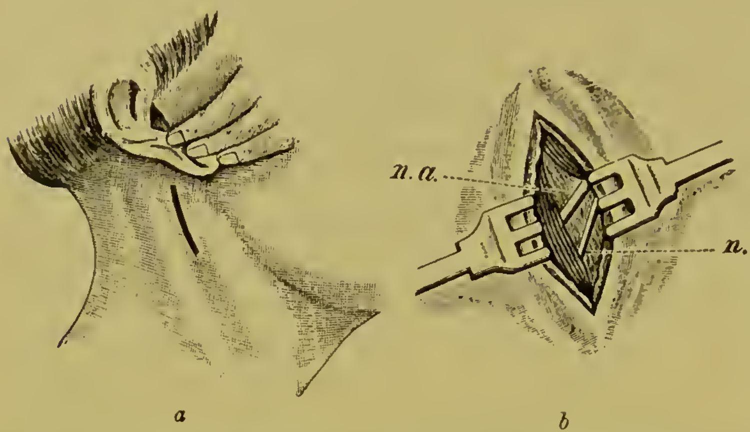


Fig. 280.—Exposure of the spinal accessory nerve: *a*, skin incision; *b*, the nerve exposed (*n. a.*); *n*, second cervical nerve.

§ 92. **Wounds of the Air Passages.**—We have already described (§ 88) subcutaneous injuries of the air passages and fractures of the cartilages of the larynx and trachea.

Open wounds of the air passages are very varied. They are most frequently caused by gunshot injuries or the knife of the suicide. In wounds of the latter class the knife usually enters the pharyngeal cavity between the hyoid bone and the thyroid cartilage, and in this way tongue, soft palate, and epiglottis may be injured. The tongue may be completely severed at its base so as to cause dyspnœa by sinking back against the posterior pharyngeal wall. All these wounds of the

upper part of the neck which penetrate into the oral and pharyngeal cavities may cause death very quickly from hæmorrhage due to injury of the lingual, the facial, the external and internal carotid arteries, or the internal jugular vein. The blood that flows into the air passages coagulates, and the patient may suffocate or die of septic pneumonia.

The transverse cuts inflicted by the suicide lower down in the vicinity of the larynx and the trachea are sometimes small and superficial. In exceptional cases, however, the larynx and œsophagus are cut through with the neighbouring soft parts, especially the vessels and nerves, and immediate death results from hæmorrhage. The most extensive and usually irregular wounds, contusions, lacerations, and fractures of the cartilages of the larynx, etc., result from gunshot injuries.

The symptoms depend mainly upon the extent of the wound and upon the associated injuries. If the larynx and the trachea are only partially divided, there is but slight gaping of the wound. If they are completely severed, the upper part is drawn upward by muscular action, while the lower part sinks downward. If the trachea is completely divided, the lower part may sink down behind the sternum so as to be seen above the manubrium sterni only during the movements caused by violent gagging and coughing.

Dyspnœa and severe coughing usually accompany large wounds of the larynx and trachea. The interference with respiration may have various causes, especially flow of blood into the lungs, displaced portions of cartilage, injury to the epiglottis, retraction of the lower fragment of the trachea, extensive collection of air (emphysema) in the cellular tissue of the neck, pressure of a large hæmatoma, etc. The patient may suffocate in consequence of coagulation of the blood that has accumulated in the lungs. Emphysema of the cellular tissue occurs particularly in connection with smaller wounds—punctures, for example—when the wound in the skin and that in the larynx or trachea do not correspond. The accumulation of air may increase rapidly and extend inwardly into the mediastinum and externally over the body even to the extremities. Of other symptoms, disturbances of speech and difficulty in swallowing (dysphagia) are prominent. The hæmorrhage is mostly the result of complicating wounds of the arteries and veins of the neck. Even if none of the larger vessels are injured, the hæmorrhage may still be profuse—e. g., from the veins which are engorged in consequence of asphyxia.

The prognosis of an important injury to the air passages is always uncertain, as so much depends upon whether the patient receives proper surgical treatment with sufficient promptness. Death often follows

the injury very quickly in consequence of hæmorrhage resulting from a wound of one of the larger arteries or veins, or in consequence of suffocation from the accumulation of coagulated blood in the lungs. Suffocation may also be occasioned by displaced portions of cartilage, by inflammatory swelling of the entrance to the larynx (œdema of the glottis) or the lower part of the trachea, by emphysema of the mediastinum or the skin, and by large hæmatomata that exert pressure.

In other cases secondary disturbances resulting from the injury are the cause of death, especially pneumonia, bronchitis, cellulitis with extensive burrowing of pus and sloughing, sepsis, secondary hæmorrhages, etc. Less frequently gangrene of the lungs is observed.

If recovery ensues, the wound when extensive takes a long time to heal. If the trachea is completely divided, an oblique position of the same is likely to result, inasmuch as the upper and lower fragments heal together with a lateral displacement. Air fistulæ, strictures, and cicatricial shortening of the vocal cords sometimes result. Air fistulæ are most commonly the result of defects in the cartilage due to the injury or subsequent suppuration. After a time these fistulæ of the larynx and trachea usually become labiform fistulæ—that is, the mucous membrane grows together with the outer skin. As air fistulæ are due to a direct union of the inverted edge of the skin with the mucous membrane, special pains must be taken to prevent this in treating wounds of the trachea with defects in the cartilage. On the other hand, an effort must be made, by aseptic treatment of the wound, to prevent suppuration and its consequences—viz., necrosis of the cartilage. In rare cases fistulæ of such size are seen in consequence of large defects in the trachea that they admit the finger, and respiration takes place through the defect. In consequence of this the upper part of the larynx contracts more and more. Strictures of the larynx, aside from cicatricial strictures, are very commonly a result of loss of substance in the trachea.

Scalds of the trachea from drinking fluids that are too hot, and burns with corrosives—such as sulphuric acid, caustic potash, etc.—should also be briefly mentioned here. In these cases the upper part of the larynx is usually involved, owing to aspiration of the injurious fluids. In exceptional instances destruction of the mucous membrane as far down as the lungs has been seen to result from the action of sulphuric acid or caustic potash, which has been taken in some cases accidentally and in others with suicidal intent. The symptoms of such injuries of the inner wall of the air passages are inflammatory swelling of the entrance to the larynx, the larynx and the trachea, with corresponding dyspnœa, aphonia, and dysphagia. The difficulty in breath-

ing may, in consequence of œdema of the glottis, for instance, reach such a degree as to render tracheotomy necessary. Strictures result, as a rule, from these scalds and burns of the larynx.

The diagnosis of a wound of the larynx or the trachea is very easy if the wound is large, as one usually sees the opening into the air passage. For the diagnosis of smaller wounds, exit of air, emphysema of the subcutaneous cellular tissue, and dyspnœa are of importance.

The treatment of injuries to the larynx and the trachea must be directed, above all, toward the prevention of suffocation. The hæmorrhage must be carefully arrested. If a large amount of blood has already entered the lungs, the patient must be made to expectorate freely, or an attempt made to suck the blood out by means of an elastic catheter. In suitable cases tracheotomy may be performed and further entrance of blood prevented by packing the larynx above the tracheotomy tube, or by inserting a so-called tampon-canula (see page 627). At the same time that tracheotomy is performed the blood clots should be removed as completely as possible from the air passages by introducing an elastic catheter to excite coughing movements, by aspirating the blood, by introducing a long, narrow, curved, sharp spoon, etc. In the after-treatment the head of the patient should be kept lowered as much as possible.

In all cases of severe injury to the larynx, tracheotomy is indicated, even though there be as yet no serious symptoms of impeded respiration. Tracheotomy is especially necessary if the patient is not under the constant watch of a physician. If the wound chances to be in a suitable place—in the trachea, for instance—it may itself serve for the introduction of the tracheotomy tube.

The wound as such is treated in accordance with general rules—that is, it is carefully examined, the hæmorrhage is arrested, etc. Wounds of the larynx and trachea should not, as a rule, be closed by suture, but should be treated as open wounds and packed aseptically. If the larynx or trachea is completely or almost completely divided, both ends should be brought together with a few apposition sutures, especially on the sides. The middle of the wound—i. e., the part in the front of the trachea—should be left open, so as to be able to introduce the tracheotomy tube here if it should prove necessary.

To prevent the occurrence of strictures as early as possible, one may, in suitable cases, insert a drainage-tube into the trachea. A silk thread is fastened to each end of the tube and carried out below through the wound in the trachea and above through the mouth, the two ends being tied together externally (Genzmer). In case of injuries below the cricoid cartilage and still lower, one silk thread is sufficient.

It is brought out through the tracheotomy wound and tied externally around the neck. Patients are nourished at first through a stomach tube.

To relax transverse wounds of the neck as much as possible, one must take pains to have the head approximated somewhat to the chest. This can be accomplished very simply by putting on a female night-cap, fastening a piece of gauze bandage to each string and tying them about the thorax.

In case of scalds and burns of the respiratory tract, especially of the entrance to the larynx, one will seek to prevent inflammatory swelling as far as possible by allowing the patient to swallow broken ice, applying ice poultices, and giving inhalations. If the patient is seen immediately after the injury, one should, first of all, neutralize the aspirated material (see also page 537, Injuries of the Œsophagus).

Among secondary conditions following wounds of the larynx and trachea, the treatment of strictures and air fistulæ is especially important. Strictures of the larynx are dilated by the introduction of bougies or tin bulbs from within the mouth, or, after tracheotomy, from the wound in the trachea. Frequently, however, nothing is accomplished in this way, and one is obliged to open the larynx and divide the cicatricial bands. After division of the stricture the insertion of a Dupuis's chimney canula (see Figs. 310 and 311) is to be recommended, and also, if necessary, the introduction of laryngeal bougies from within the mouth or through the tracheotomy wound. In this way I have recently cured three very severe cases.

In the worst cases the patient is often obliged to wear a tracheal tube for the remainder of his life. If there is aphonia resulting from extreme cicatricial contraction—for instance, in the region of the vocal cords or after destruction of the cords themselves—one may introduce a phonation canula; that is, a so-called artificial larynx made according to Gussenbauer's, Wolff's, or Burns's model (see page 000). Patients can sometimes, however, make themselves understood even after complete destruction of the vocal cords, inasmuch as the false vocal cords and the superior aperture of the larynx assume the function of the vocal cords (see also page 632).

In treating smaller air fistulæ, freshening by means of an elliptical incision and deep linear suture are sufficient. The edges of the wound must be made sufficiently movable by dissecting them up from the subjacent parts. Sometimes lateral liberating incisions are serviceable. One can cure even large fistulæ in this way. More extensive fistulæ or defects should be freshened and covered with pedunculated flaps of skin taken from the neighbourhood. A small drainage-tube should be

inserted beneath the flap for a day or two, to prevent emphysema. The healing process is aided by applying an aseptic compressive dressing.

§ 93. **Injuries of the Œsophagus.**—Injuries of the pharynx have already been discussed (§ 64, page 405).

Injury to the œsophagus alone is comparatively rare. It is usually combined with injury of the trachea, especially when arising from an incised, punctured, or gunshot wound. In case of injury to the pharynx and œsophagus from the last-named cause, the ball may rebound from the cervical vertebræ, be swallowed, and pass off *per rectum*.

Injuries from within the œsophagus are of special importance. These injuries may occur, for example, from foreign bodies that have been swallowed, or from the unskilful introduction of an œsophageal bougie in case of stricture of the œsophagus, particularly from carcinoma. In such cases of complete rupture of the œsophagus the foreign body or the œsophageal bougie passes into the mediastinum or the pleural cavity, and suppurative mediastinitis and empyema with fatal termination are the usual result.

Spontaneous rupture of the œsophagus sometimes occurs, particularly among drinkers, from vomiting or retching after taking a large amount of food or drink. The rent is always found, according to Zenker and Ziemssen, near the cardiac end, and death usually occurs within twenty-four hours from the passage of the contents of the stomach into the mediastinum and into the pleural cavity. In such cases there is probably a softening or sort of self-digestion in the lower part of the œsophagus, whose power of resistance has already been weakened by the excessive use of alcohol.

Perforations of the œsophagus may also arise from different diseases of the same and its surroundings—e. g., from carcinoma of the œsophagus, the larynx, and its neighbourhood, or from other tumours, abscesses, or aneurisms. Perforation of the œsophagus and the descending aorta from carcinoma or a foreign body has been repeatedly observed. The œsophagus has also been found to communicate with the internal carotid, the subclavian, and the pulmonary artery, or, according to König, with smaller vessels—the vena azygos minor, for instance, or the inferior thyroid artery—after perforation of the œsophagus and the vessels named by a foreign body.

All incomplete divisions of the œsophagus from within or from without have, of course, a much more favourable prognosis than complete ruptures.

The symptoms of an injury to the œsophagus are pain on swallow-

ing, hæmatemesis, and, in case of open wounds, escape of solid and fluid food through the wound. In case of puncture of the œsophagus, every sure symptom may fail. If it is completely divided, the lower portion sinks more or less. If there is simultaneous injury of the trachea, mucus and food pass into it, and there follow dyspnœa and severe coughing, and later, bronchitis and pneumonia. Cellulitis and extensive burrowing of pus, with death from general sepsis or pyæmia, result from the escape of particles of food into the cellular tissue around the œsophagus (see also Inflammations on the Neck, § 94, page 538). The greatest danger in this connection arises from injury to the thoracic portion of the œsophagus with escape of food into the mediastinum and into the pleural cavity, and subsequent suppuration (mediastinitis and empyema).

The diagnosis of injury to the œsophagus is easiest in case of external wounds where there is an escape of food through the wound. In all other cases the diagnosis may be difficult.

The prognosis of an injury to the œsophagus depends principally upon the complications—e. g., injury of the vessels or of the air passages—upon the higher or lower position of the injury, and upon whether the escaped particles of food have already led to septic inflammation of the mediastinum or not. According to Schüller, of forty-eight cases of injury to the œsophagus and the trachea, only eight were fatal. Among secondary conditions, fistulæ and strictures of the œsophagus are of particular importance. If recovery follows simultaneous injury of the œsophagus and the trachea, the wound in the œsophagus usually closes first. A fatal termination may result partly from the associated injuries—e. g., from hæmorrhage in case of injuries to the vessels—and partly from cellulitis, burrowing of pus, and sloughing, with septicæmia or pyæmia, in consequence of the escape of food into the surrounding cellular tissue, into the posterior mediastinum, and into the pleural cavity. If there is simultaneous injury of the trachea, death may ensue from suffocation resulting from the aspiration of blood, mucus, and food into the lungs.

Fatal hæmorrhage has also been seen to follow the bursting of varicose veins of the œsophagus (Rokitansky, König). The latter (see Fig. 335, page 643) occur most commonly in connection with disturbance of the portal circulation in cirrhosis of the liver. The veins of the stomach and of the œsophagus receive, as is known, blood from the portal vein, and carry it into the vena azygos major. In case of circulatory disturbances, the veins of the stomach and œsophagus may distend so as to form marked varices. König saw death result from the bursting of a varix near the cardiac orifice in a case of syphilitic hepatitis.

Burns of the œsophagus result from the swallowing of too hot fluids, especially by children, and of sulphuric acid, hydrochloric acid,

nitric acid, caustic potash, etc., either accidentally or with suicidal intent.

The symptoms of these burns vary very much, according to the degree of the injury. In a severe burn of the œsophagus, when, for example, a considerable amount of strong sulphuric acid is swallowed, there is an extensive or complete destruction of the mucous membrane of the pharynx and the œsophagus as far as the stomach, attended even by perforation of the latter. From swallowing diluted caustics or very hot fluids a more superficial destruction or inflammation of the mucous membrane results.

The symptoms conform to the amount of destruction of tissue that takes place. They consist mainly of pain, dyspnœa, gagging, vomiting, etc. In severe cases of burns of the œsophagus due to the above-mentioned concentrated fluids, death may ensue within twenty-four hours, or within the next few days, from increasing collapse or from sepsis.

Treatment of Injuries to the Œsophagus.—The first question that arises is, Should a divided œsophagus be sutured or not? Schüller expresses himself in favour of suture. Favourable results have been observed both with and without its use. In case of complete division of the œsophagus, one will always approximate the lower fragment to the upper one by means of sutures, to prevent the sinking of the former, provided, of course, that the injury to the œsophagus is in the region of the neck and not too deep in the thoracic cavity. This can be accomplished either with a few tension sutures or by a complete circular suture. The external wound should then be packed with iodoform gauze. In order to expose the wound in the œsophagus sufficiently, it is often necessary to enlarge the external wound. Punctured wounds of the œsophagus often heal spontaneously without being recognised, and sutures are unnecessary. As soon as any symptoms of inflammation or a phlegmon make their appearance in connection with probable injury to the œsophagus from without or from within, the site of the injury should be sufficiently exposed immediately, if possible, after enlarging the external wound in the neck, and the wound in the œsophagus closed by sutures. One must, above all, prevent burrowing of pus in the direction of the mediastinum by packing the wound with iodoform gauze and keeping the head low.

The patient is fed with nutrient enemata or by carefully introducing a stomach tube.

In case of burns of the œsophagus from swallowing a strong solution of sulphuric acid, nitric acid, hydrochloric acid, caustic potash, etc., the fluid should, first of all, be neutralized as soon as possible. If it is an alkali, vinegar, vegetable acids, or oil are given. If it is an

acid, a mixture of chalk, carbonate of potash, and magnesia is given, and the patient made to drink a large amount of water. The stomach pump should be introduced, of course, as soon as possible. A quantity of water or milk is allowed to pass into the stomach, and the latter is then thoroughly pumped out. The stomach is pumped out as follows: A stomach tube is introduced, and, by means of a stomach pump—i. e., an aspirating syringe—the stomach is filled with lukewarm water, which is then aspirated again. Washing out the stomach by the siphon process is still more simple. A glass funnel is attached to the upper end of the stomach tube, or an ordinary irrigating tube, and by lowering the funnel or the irrigator after a considerable amount of lukewarm water has passed in, the stomach is emptied by siphon action (see § 165, Surgery of the Stomach). After repeatedly filling and emptying the stomach with lukewarm water, milk, farinaceous soup, and barley water are finally given. Chopped ice is also used, and morphine administered hypodermically. Fluid diet must of course be adhered to for a time, it being very important to guard against errors in this direction. Subsequent strictures of the œsophagus must be prevented as far as possible by the frequent introduction of bougies.

Fistulæ of the œsophagus, if small, may be closed by the use of the cautery, by freshening and suture, or by a plastic operation—that is, by covering them over with pedunculated flaps from the neighbourhood.

Strictures must, as has been said, be prevented after injuries by the use of bougies. If a stricture already exists, it should be dilated by the introduction of œsophageal bougies passing gradually from the lower to the higher numbers, and allowing them to remain sometimes for a shorter and sometimes for a longer time (see § 111). If this treatment has no effect, or if the stricture is impassable for bougies and food, an operation is indicated. If it is situated high up, it can be divided or resected from within or from without (œsophagotomy, resection of the œsophagus). If the stricture is a long one and situated low down, and not suited for division, gastrostomy may be performed in order to give the patient sufficient nourishment. For a description of œsophagotomy, resection of the œsophagus, and gastrostomy, the reader is referred to Diseases of and Operations on the Œsophagus and Stomach (see §§ 114, 165).

§ 94. **Inflammatory and Suppurative Processes in the Neck.**—Inflammations in the neck are very frequent, especially secondary ones, following primary inflammations of the head. This is because the numerous lymphatics of the face and skull open into the lymph channels of the neck. This also explains why it is that the lymph glands of the

neck are so frequently the seat of infection from microbes which get into the circulation from the facial cavities.

Inflammation and suppuration in the neck may be either acute or chronic. They are in part circumscribed, in part diffuse, with a pronounced tendency to further extension.

The arrangement of the fasciæ and the connective-tissue spaces is of the greatest importance in connection with the extension of inflammatory processes, especially acute and chronic suppuration, inasmuch as their extension is checked by the fasciæ and favoured by the cellular-tissue clefts. Every surgeon must therefore have an exact knowledge of the anatomy of the cervical fasciæ and the connective-tissue spaces that lie here, as he is thus better able to prevent the dangerous extension of suppurative processes in the neck to the thoracic cavity. We are under obligation to Henke, Bichat, König, and others for their researches on this subject. The former, for example, studied the topography of the fasciæ and the connective-tissue spaces by injecting water into the arteries under high pressure, thus producing artificial œdema, letting the cadaver or parts of the cadaver freeze, and cutting sections. Poulsen and others determined the arrangement of the connective tissue and fascial clefts by injections of glue.

According to Henke and König, the following larger connective-tissue spaces are of special significance in connection with the spread of inflammatory processes. They communicate partly with each other and partly with the thoracic cavity, presenting, as it were, a continuation of its subserous spaces.

Of the connective-tissue spaces of the neck which are in pairs, the one corresponding to the position of the large vessels and that inclosing the sterno-mastoid are particularly important. The so-called antivisceral or previsceral space, in which the larynx and trachea lie, is single, as is also the retrovisceral space for the œsophagus. The space in which the submaxillary gland lies covered by the firm suprahyoid fascia communicates with the interstices that have been mentioned, as does also the large intermuscular space of the axilla. The latter corresponds in position to the large vessels and nerves coming from the neck. The previsceral space containing the larynx and trachea, and the retrovisceral space containing the œsophagus, as well as the one containing the blood-vessels, communicate with the thoracic cavity and with each other, and are also connected with the subcutaneous cellular tissue. Suppurative processes can thus easily spread from these spaces to the thoracic cavity and pass from one space to another.

The previsceral and the retrovisceral spaces are to be looked upon as continuations of the anterior and posterior mediastinum, and König properly designates them as mediastinum colli. The trachea passes above the arch of the aorta from the anterior into the posterior space, and the previsceral continues on into the anterior mediastinum. At this place suppuration can easily be spread to both mediastina. The space containing the internal carotid and the internal jugular vein likewise communicates between the two apices of the pleura with the retrovisceral and previsceral space, and all three then extend on into the anterior and posterior mediastinum.

The escape of pus in the lateral region of the neck is made especially difficult by the firm union of the platysma with the skin and by the fascia. The

platysma is, on the other hand, only loosely connected with the superficial fascia, and suppuration on the inner surface of the platysma can therefore spread on to the thorax. Subcutaneous suppuration in the median line of the neck can likewise spread with ease to the thoracic wall without entering the thoracic cavity.

The most important groups of lymphatic glands are the submaxillary glands at the angle of the jaw, which, in case of disease—e. g., carcinoma of the lip, the tongue, or the mouth—are first attacked. The lymph vessels coming from the submaxillary lymph glands pass over into those of the upper superficial and deep cervical glands. The former lie chiefly on the inner and outer borders and on the outer surface of the sterno-mastoid muscle, and the deep ones lie about at the point of division of the common carotid, and along the internal jugular vein. The lower superficial and deep cervical glands lying in the supraclavicular fossa, the glands of the axilla, and those of the anterior and posterior mediastinum (mediastinal glands), are the next reservoirs of lymph. The vasa efferentia of the lower deep lymphatic glands of the neck unite for the most part to form the truncus lymphaticus jugularis, which opens on the left side into the thoracic duct and on the right into the truncus lymphaticus communis, or into the subclavian or internal jugular vein.

The clinical course of inflammatory and suppurative processes in the neck varies very much, according to their cause and location. Generally speaking, abscesses are most frequently found in the submaxillary region and in the spaces for the large vessels.

Superficial inflammation and suppuration beneath the skin and the platysma originate partly from the lymphatic glands in this region, or they may develop in connection with diseases of the lower jaw, particularly alveolar abscesses, or in consequence of the breaking through of a suppurative inflammation of the parotid, submaxillary, and sublingual glands. The inflammatory processes that originate in the lymph glands are more frequently chronic than acute, and most commonly of a tubercular or syphilitic nature, while the acute progressive inflammations and abscesses are chiefly the result of acute affections in the neighbourhood of the lower jaw and salivary glands. Acute inflammations of the glands of the neck are observed very frequently among children, resulting from infection through the lymphatics which run into them.

The subacute or more chronic tubercular lymphomata form characteristic circumscribed swellings of the side of the neck near the angle of the jaw, which consist of groups of enlarged lymph glands. The process begins with hyperplasia of the lymph glands, which then goes on to caseation or abscess formation. External fistulæ often exist which usually lead into the tubercular lymph glands. The latter not infrequently become calcified, presenting chalky formations which are

as hard as stone. Enlarged tubercular glands near the epiglottis, and anywhere near the upper part of the larynx, may cause serious difficulty in respiration from pressure on these parts as well as from pressure on the recurrent laryngeal nerve in case deeper lymph glands are affected.

Deep inflammations of the side of the neck are usually situated in the connective tissue that surrounds the vessels, beneath the sterno-mastoid muscle. They are likewise in part due to primary disease of the deeply seated lymph glands of the neck, and are in part secondary

FIG. 281.—Actinomycosis of the right side of the neck in a peasant thirty years of age caused by infection from the mouth; there are numerous fistulæ leading to pus foci with indurated surroundings; recovery.

to inflammatory and suppurative processes on the head, or they may be metastatic in origin. These deeper inflammations and suppurations most frequently follow diseases of the facial cavities, the jaws, particularly the lower jaw, the teeth, the salivary glands, the cervical vertebræ, and the mastoid process, or they may develop in the course of diphtheria, scarlet fever, typhoid fever, pyæmia, septicæmia, tuberculosis, etc. The course is acute or chronic, according to the nature of the primary affection.

Actinomycosis sometimes occurs in the neck (see Principles of

Surgery, § 86), originating mainly from infection through the mouth (Fig. 281). It sometimes takes the form of a phlegmonous inflammation with subsequent breaking down of tissue, and sometimes the formation of granulations or induration of the involved part of the neck is predominant.

The so-called angina Ludovici, situated in the region of the submaxillary and the neighbouring lymph glands, is a form of acute deep phlegmon. This has already been described on page 490.

There remain to be mentioned the deep inflammations and suppurations in the neck in the vicinity of the trachea and œsophagus—that is, those in the previsceral and the retrovisceral connective-tissue spaces of the neck. They occur especially after injuries and after operations in this region that are not performed aseptically.

With reference to the clinical course of deep inflammations and suppurations in the neck, the circumscribed are to be distinguished from the progressive and the acute from the chronic.

Deep, acute, spreading phlegmonous suppurations in the neck are always to be regarded as serious affections, since they may very quickly have a fatal termination from involvement of the mediastinum and the pleura, if a prompt incision is not made for the escape of the pus. I saw a case of gangrenous alveolar periostitis resulting from the rough extraction of a tooth, and the patient died in four days from mediastinitis and sepsis. I first saw the case on the third day, and immediately made numerous incisions and provided for drainage, but the patient could not be saved.

We have already emphasized the fact that all deeply situated suppurative processes in the neck are much more likely to spread along the natural clefts in the tissues than to break through externally.

In case of deep phlegmons of the neck, the head is usually inclined to the diseased side, and the neck is not infrequently so infiltrated that it is as hard as a board. Respiration may be interfered with to such a degree from pressure on the region of the tonsils and upon the aperture of the larynx, by a swelling in the vicinity of the epiglottis or by direct extension of the swelling to the larynx, as to necessitate tracheotomy. Other symptoms are caused by pressure on the vessels, the nerves, the trachea, and the œsophagus. Difficulty in mastication and deglutition is always present in connection with extensive, deep phlegmons, especially those near the pharynx and œsophagus. Dilatation or contraction of the pupil arises from irritation or paralysis of the sympathetic nerve. Pus sometimes ruptures into the trachea, less frequently into the œsophagus. Extension of the phlegmon to the thoracic cavity, however, is always the greatest danger (anterior or

posterior mediastinitis, empyema, suppurative pericarditis, and abscess of the lungs, with pyæmia or sepsis).

It is only in exceptional cases that a phlegmonous suppuration of the neck, extending down behind the sternum, breaks through externally without involving the thoracic cavity, as, for example, in a case of König's, in which the process came to the surface between the first and second ribs.

Deep subfascial phlegmons of the neck sometimes extend to the axilla by following the brachial plexus and the large vessels. Pain on motion, especially on raising the arm, and œdema, are indications of threatened or already existing involvement of the axilla. One not infrequently feels fluctuation in such cases above and below the clavicle. Suppurative processes of this sort sometimes break through in the region of the scapula, or at least make their appearance here beneath the skin.

Septic and diphtheritic inflammations are the most unfavourable forms, and with these extensive necrosis of the tissues is not infrequently observed.

All circumscribed, acute, deep suppurative processes in the neck are more favourable, but one must always keep in mind that from any circumscribed abscess a progressive suppuration with all its dangers may at any moment arise.

Chronic, deeply seated suppurative processes in the neck are chiefly of tubercular nature. They are in part circumscribed tubercular inflammations and suppurations of the lymph glands, or circumscribed carcinomatous processes in the vicinity of the œsophagus, for example, or so-called chronic or cold gravitation abscesses following tubercular inflammation (caries) of the cervical vertebræ or of the mastoid process. They may also follow chronic suppuration in the neighbourhood of the lower jaw, the hyoid bone, and the larynx. Caries of the cervical vertebræ is particularly likely to cause retropharyngeal spinal abscesses (see § 146, Diseases of the Vertebral Column). Cold abscesses resulting from the breaking through of a suppurative inflammation of the mastoid antrum may descend along the deep muscles of the neck as far as the axilla or beneath the scapula. Cold abscesses also burrow in the opposite direction, from below upward, frequently extending along the sterno-mastoid muscle, for example, in caries of the sternum. An empyema, a cavity, or an abscess of the lung may also break through externally above the sternum or the clavicle, or give rise to suppuration, which extends farther upward along the vessels of the neck.

In all suppurative processes in the neighbourhood of the vessels there is always the danger of ulcerative destruction and perforation of

the walls of the vessels, or of the formation of thrombi in the veins, which may undergo a puriform softening and be swept off into the circulation, causing a general infection (pyæmia, or miliary tuberculosis).

Perforations of the vessels of the neck from suppuration seldom occur, being most frequent in tubercular suppuration and in abscesses following scarlet fever in children with extensive necrosis of the tissues. According to König, almost every artery and vein of any size in the neck has been injured in this way, especially the large vessels (the innominate artery and vein, the subclavian artery, the arch of the aorta, the common carotid, the internal jugular vein, etc.). In such cases fatal internal hæmorrhage may ensue at once. Hæmorrhage has sometimes not occurred until during or after incision of the abscess. There are cases, however, in which no hæmorrhage takes place, because the vessel is closed by a thrombus before complete opening of its wall, coagulation of the blood having been caused by pressure on the vessel or by inflammation of its wall. This occlusion of the vessels by a thrombus is observed, as is well known, especially in the veins, much less frequently in the arteries. If the thrombi become infected, break down, and are swept away by the blood current, metastatic pyæmia takes place in case of suppuration, and general miliary tuberculosis in case of tubercular thrombi. If large thrombi get into the circulation from the internal jugular vein, for example, immediate death may occur from embolism of the pulmonary artery. If smaller plugs become lodged in the branches of this artery, pulmonary infarcts are formed.

For the diagnosis of an inflammation and suppuration in the neck, the swelling and, in case of suppuration, the fluctuation are especially important. Both symptoms are most pronounced in circumscribed inflammatory processes. In diffuse inflammations the detection of fluctuation may be more difficult. Indications of pus, aside from fluctuation, are the presence of certain localized points of tenderness and of œdematous areas or of gaps in the hard, infiltrated tissue.

We have already spoken sufficiently of the prognosis of inflammations and suppurations in the neck. The earlier the pus is evacuated, by making an incision, the better the prognosis. Diffuse, progressive, deep phlegmons of the neck are, to be sure, the most unfavourable cases, but a circumscribed abscess also, in the neighbourhood of the epiglottis or the upper aperture of the larynx, for example, may become dangerous from pressure upon the latter, or from perforation into the air passages.

The treatment of every acute suppuration in the neck consists in making as prompt an incision as possible, even though fluctuation can not be made out. Further extension of the process is in this way most quickly and surely prevented. All incisions in the neck should be made in a longitudinal direction. The number of incisions depends

upon the extent of the suppuration, and it is better to make too many than too few. Incisions should also be made along the periphery and in the most dependent portions. If the process is deep, skin and fascia are divided with the knife, and the opening is deepened with the handle of the scalpel, a closed dressing forceps, or a probe. Injury to the vessels and nerves is most surely avoided in this way. One must always think of the possibility of burrowing of pus. The after-treatment consists in irrigating out the pus focus with 1-to-1,000 bichloride, sufficient drainage to provide for the escape of pus, gauze packing being used in large abscesses. By keeping the head lowered, one may prevent the burrowing of pus in the direction of the thoracic cavity.

In chronic tubercular abscesses the pus focus is energetically scraped out with a sharp spoon after it has been thoroughly laid open. One should, if possible, completely remove suppurating tubercular lymph glands and not be content with scraping. Such extirpation of tubercular lymph glands, particularly in the neighbourhood of the large vessels, is often, it is true, a very difficult operation. Their removal is accomplished most easily by dividing the surrounding tissues down to the surface of the lymph gland with curved scissors or the knife.

The remainder of the treatment of inflammations and suppurations is symptomatic, depending upon the existing complications. If there is danger of asphyxia, for instance, tracheotomy may become necessary.

Retropharyngeal and Retro-œsophageal Inflammations.—Retropharyngeal and retro-œsophageal inflammations and suppurations between the pharynx and the œsophagus in front, and the cervical portion of the vertical column behind, form a special variety among the deeply seated inflammations of the neck, and it is therefore necessary to take these up a little more in detail. The point of transition from the pharynx to the œsophagus lies behind the cricoid cartilage. Inflammations of the retropharyngeal and retro-œsophageal space originate for the most part in the pharynx, the œsophagus, or the cervical vertebræ. Other deeply seated inflammations of the neck, beginning, for instance, in the connective-tissue spaces about the vessels, less frequently spread to the retrovisceral space (see page 539).

In this category belong (1) the acute septic phlegmon following injuries and perforations of the posterior pharyngeal wall and the œsophagus—e. g., from a foreign body, carcinoma, etc.; (2) the so-called idiopathic acute retropharyngeal abscess, particularly among children; (3) acute secondary inflammation and suppuration following disease of the pharyngeal mucous membrane, in connection with scarlet fever, for instance, and from the extension of other inflammations of the

neck; (4) the chronic tubercular cold abscess following tubercular spondylitis of the cervical vertebræ. For inflammations of the pharynx itself the reader is referred to §§ 66–68.

We will here consider briefly the symptomatology of the especially important forms of acute and chronic retropharyngeal suppuration.

The symptomatology of retropharyngeal abscesses is briefly as follows: The pharyngeal wall is lifted from the vertebral column by the abscess and bulges forward correspondingly, and the superior aperture of the larynx and the œsophagus may in this way be more or less narrowed or closed. If the suppuration increases, the pus burrows usually downward along the posterior surface of the cricoid cartilage, and may from here leave the retrovisceral space and, following the inferior thyroid artery, enter the connective-tissue space about the vessels, so that it finally points at the inner or outer side of the sterno-mastoid muscle.

In another class of cases the retropharyngeal suppuration spreads downward along the œsophagus into the posterior mediastinum, and may here, according to König, pass beneath the arch of the aorta into the previsceral space (see page 539) and perforate into the pericardium or the pleural cavity. Less frequently the œsophagus becomes separated on all sides from the surrounding tissues, and least frequently retropharyngeal suppurative processes spread in the direction of the lower jaw and the parotid gland.

The acute retropharyngeal abscess, our knowledge of which has been recently advanced by Bókai particularly, is of especial interest. The disease is not frequent; it is most common in children from the first to the third year. Inflammatory processes in the naso-pharyngeal space and in the pharynx—e. g., coryza or pharyngitis, scarlet fever, typhoid fever, erysipelas, diphtheria, etc.—are the chief causes. Micro-organisms pass from the naso-pharyngeal space into the retropharyngeal lymph glands, especially those at each side of the vertebral column near the second and third cervical vertebræ, and also those on the posterior surface of the buccinator muscle, and then these glands suppurate and form an abscess.

The extent of these acute retropharyngeal abscesses in children is very variable. They usually reach to about the fifth cervical vertebra, and may then, in the manner described on page 539, burrow downward, laterally, or more rarely upward. The abscesses break through into the pharynx or the œsophagus, or they may rupture into the mediastinum or the pleural cavity, or may point near the inner or outer border of the sterno-mastoid, or, less frequently, in the carotid region, on the face, or at the angle of the jaw.

Among the symptoms of acute retropharyngeal abscess in children are pain and dysphagia. The latter may be such as to prevent taking nourishment of any kind into the œsophagus. In addition to difficulty in swallowing, there are also disturbances of speech and respiration. The child speaks as if he had a lump in his throat, and breathes with open mouth because the posterior nares are obstructed by the abscess. Attacks of asphyxia often occur during sleep if the mouth is closed. From direct pressure of the abscess upon the air passages, or in consequence of inflammatory œdematous swelling about the superior aperture of the larynx, the same symptoms of stenosis of the larynx may arise as in croup and diphtheria. If tracheotomy is not performed promptly, or the pus evacuated, death from asphyxia not infrequently occurs. Rigidity of the neck and a slight backward inclination of the head are also characteristic of acute retropharyngeal abscess. If the inflammation spreads to the region of the lower jaw, inflammatory lockjaw usually follows.

On examination of the patient, one usually finds an inflammatory swelling beneath the lower jaw, particularly in the submaxillary region, and one sees on looking into the pharynx, particularly in adults and older children, that the posterior pharyngeal wall bulges forward either in its entire extent or on one side near the tonsil and the posterior pillar of the soft palate. By palpation with the finger one can make out fluctuation and determine the size of the abscess. One must also carefully examine the region of the angle of the jaw and the neck with the finger to ascertain whether there is fluctuation here also.

The prognosis of an acute retropharyngeal abscess is most likely to be favourable if it has been recognised early and incised. Septic, diphtheritic, and scarlatinous abscesses are the most unfavourable. The age of the patient is of considerable importance for the prognosis. The younger the child, the more is marked stenosis of the larynx to be feared, and the more likely is pneumonia or suffocation from aspiration of pus into the air passages to occur after spontaneous or unskilful opening of the abscess.

The course of a retropharyngeal abscess following tubercular spondylitis (caries) of the cervical vertebræ is very chronic. The pain, the rigidity of the neck, and the deformity of the cervical portion of the vertebral column usually permit an early diagnosis before the abscess is visible in the pharynx. The subjective symptoms caused by these abscesses which develop so slowly are often very slight. If the abscess has descended into the pharynx, one feels or sees that the mucous membrane of the posterior pharyngeal wall bulges forward, and fluctuation can be easily made out by palpation.

Regarding other symptoms and the extension of chronic retropharyngeal abscesses, the reader is referred to what has been said above concerning acute abscesses, and to page 539.

The prognosis of tubercular retropharyngeal abscesses is not favourable. They can only be cured when their cause—caries of the cervical vertebræ—is removed. In tubercular inflammation of the cervical vertebræ with retropharyngeal spinal abscesses death usually results from general tuberculosis or phthisis with increasing marasmus. The fatal termination sometimes follows quickly as the result of complicating pyæmic or septic intoxication. In rare cases the carious focus gradually heals.

The treatment of acute retropharyngeal abscesses consists, above all, in opening them as soon as possible. In urgent cases, when stenosis of the larynx and dysphagia are increasing, one should make an incision, even though no fluctuation can be made out.

The incision in retropharyngeal abscesses is made either from within the mouth or, better, from the outside. If made from within the mouth, the patient sits with his head inclined forward, anæsthesia being unnecessary. Should the latter, however, be employed, the operation is performed with the head hanging over the end of the table, as otherwise, in spite of all precautions, pus is aspirated into the air passages and suffocation may ensue. The special knives made for opening these abscesses (pharyngotomes) are not necessary. One may make use of a pointed scalpel or a bistoury, which can be covered with adhesive plaster nearly to its point, so as to prevent accidental injury, especially to the tongue. The teeth are held apart, if necessary, by a mouth gag. If the incision can not be made under the guidance of the eye, the knife is passed along the left forefinger, which is protected, if necessary, by a metallic sheath, and the incision is made directly beside or above the palpating finger tip. To prevent the aspiration of pus into the air passages one will at first, in case the operation is not performed with the head hanging backward, make only a puncture, and so let the pus escape in a small stream. This puncture can afterward be enlarged as necessity may require. The opening made by the incision must be kept open for a few days by inserting a probe or by cauterization with the nitrate-of-silver stick to prevent its too prompt adherence and consequent retention of pus. One must always guard against a possible burrowing of pus externally in the neck, and, if necessary, make incisions here also.

It is easier and more advisable to open retropharyngeal abscesses externally from the neck (H. Burckhardt, Chiene, Sacchi). In Burckhardt's method an incision is made through the skin and platysma along

the inner border of the sterno-mastoid muscle at the level of the larynx. The vessels running to the thyroid gland on a level with the thyroid cartilage are retracted outward. One now passes bluntly through the loose cellular tissue keeping close to the larynx, as far as the inner side of the common carotid, which has here no branches. One then makes, close beside the larynx or the lower end of the pharynx, a small incision into the indurated cellular tissue, widens it with a dressing forceps, and thus gains access to the retropharyngeal space. The method devised by Chiene and Sacchi is very simple and free from danger. They recommend making an incision downward from the mastoid process along the posterior border of the sterno-mastoid muscle, and then, after division of the deep fascia, working in directly to the transverse processes of the cervical vertebræ. The muscles, together with the nerves and vessels, are drawn forward with a blunt retractor. One now passes the finger, a probe, or a dressing forceps along the vertebral column until the abscess is opened. The vessels of the neck are in this way entirely avoided.

In opening a retropharyngeal abscess, injury to the internal carotid artery is conceivable, as it is sometimes surrounded by pus.

Chronic retropharyngeal abscesses should also be promptly incised, before they have burrowed too far downward. If possible, one should scrape out the tubercular focus with a sharp spoon, with the head hanging over the end of the table. For the treatment of inflammations of the cervical vertebræ the reader is referred to Diseases of the Spine (§ 146).

The after-treatment following incision consists in insufflation of small amounts of iodoform and in gargling with boric acid, permanganate of potash, or chlorate of potash. For some days a fluid diet should be maintained.

§ 95. **Aneurisms of the Neck.**—As regards aneurisms and their general treatment, the reader is referred to § 95, page 530 ff., of Principles of Surgery. Only the following brief statement need be added here with reference to aneurisms of the neck:

Aneurisms of the neck result most frequently from subcutaneous injuries or from small external wounds, especially punctures, in which the free escape of blood is prevented. There is first an extravasation of blood resulting from the injury to the vessel, a hæmatoma or so-called traumatic aneurism, and there finally arises from what was at first a thrombus on the side of the vessel a sac communicating with the lumen of the artery whose wall is made up of the external layers of the thrombus, the surrounding soft parts, and new connective tissue.

In addition to these traumatic aneurisms of the arteries of the neck,

there are also true aneurisms which result, as is well known, from gradual enlargement of the lumen of the vessel in consequence of chronic endarteritis. The aneurism is cylindrical, fusiform, or sacculated, depending upon whether the enlargement affects the entire transverse section of the artery or only a part of it. Arterio-venous aneurisms also occur in the neck, in which, as is well known, there is a communication between the artery and the corresponding vein. These usually result from simultaneous injury of both artery and vein.

Aneurisms of the neck may reach a great size, and it is then often difficult to determine precisely their origin. The history given by the patient will, as a rule, however, guide one to the right conclusion. Aneurisms of the subclavian are particularly apt to attain a great size. They may fill the upper aperture of the thorax and the supraclavicular fossa, and finally enlarge upward on the neck or toward the axilla and the scapula. The subjective symptoms caused by aneurisms of the neck arise particularly from pressure upon the veins, the nerves, the trachea, the œsophagus, and the cervical vertebræ. As is true of all aneurisms, there is danger here of rupture, which is more frequently internal than external. A spontaneous cure from organization of the thrombi or from calcification occurs only in small aneurisms and particularly in those that are sacculated, with dilatation of a part of the wall of the vessel. Aneurisms of the neck may also prove fatal in consequence of cerebral embolism when clots are set free, particularly from an aneurism of the common carotid artery. One should always keep this fact in mind and be on his guard against too rough palpation of carotid aneurisms, as clots may be loosened in this way, and death from embolism of the brain is then possible (Esmarch). Aneurisms of the vertebral artery are also of great interest, of which Matas has collected a number of cases. The eleven cases of intracranial aneurism of the vertebral artery all terminated fatally; among twenty traumatic aneurisms of this artery, six were cured by operation. For the bad prognosis of wounds of the vertebral artery see page 512.

For the diagnosis of aneurisms of the neck, as well as for that of all other aneurisms, the true (not communicated) pulsation and the friction sounds, as well as the disappearance of these signs upon compression of the afferent artery, are important. Even skilled surgeons, however, have made blunders and mistaken aneurisms for tumours of a different character—e. g., for vascular sarcomata or even for abscesses, in those cases especially in which the aneurisms were combined with induration, swelling, or inflammatory symptoms in the soft parts.

The treatment of aneurisms in the neck conforms to the rules given in Principles of Surgery. This treatment undergoes, it is true, several

modifications when applied to the neck. Compression, digital as well as instrumental, is often not applicable in this region, but it should be tried in suitable cases of aneurism of the common carotid. Of operative methods, proximal ligation (Hunter) or distal ligation (Wardrop, Brasdor, Desault) are the best suited to anenrisms of the neck. The former is particularly to be recommended for those of the common carotid, the latter for those of the subclavian and innominate (Bergmann). Inasmuch as aneurisms in the neck usually have a fatal termination, operations upon them, even though they endanger life, are warranted. These operations have lost a great deal of their danger now that they are performed under aseptic precautions. Proximal and distal ligation with incision or extirpation of the sac (after Antyllus) would only be possible in the case of the common carotid and its branches. Keen cured an arterio-venous aneurism of the common carotid and the internal jugular vein by double (proximal and distal) ligation of the vessels named with splitting of the sac. Hunter's method of proximal ligation of the artery is in general surer than that of Wardrop and Brasdor, because after Wardrop's distal ligation the circulation in the aneurismal sac is maintained more or less by means of the branches that go off from it.

For the methods of ligating the different vessels the reader is referred to § 90.

Of other methods of treating aneurisms I wish especially to recommend electro-puncture or galvano-puncture, particularly for cases in which other (operative) treatment is no longer possible. After the experience which I have had in treating aneurisms of the aorta by galvano-puncture, I can decidedly recommend it for aneurisms of the neck. For the details of galvano-puncture the reader is referred to Principles of Surgery, page 79, and to § 131 of this work (Aneurisms of the Aorta).

The application of the galvanic current, together with the internal administration of iodide of potassium, seems to have been attended with good results in many cases. Finally, the attempt has been made to cause a coagulation of the blood in the aneurismal sac by injecting ergotine, liquor ferri chloridi, alcohol, etc., or by the introduction of foreign bodies (catgut, silver, steel or copper wire, horsehairs, laminaria). Philippe was successful in his experiments on the common carotid and femoral arteries in dogs. The results in man have been very unfavourable. Of thirty-four patients treated for aneurism by the introduction of steel or copper wire (filipuncture) after Moore, thirty died soon after the operation (Verneuil), two were entirely cured (Coreta and Van der Meulen), and two were partially cured. For the purpose of exciting

a more energetic thrombus formation, Nancrede recommends, besides rest in bed, suitable diet, distal ligation or compression as practised by Macewen, the introduction of needles from one half to one and a half millimetres in thickness, which are left *in situ* for a few hours or up to forty-eight hours, and with which the inner wall of the sac is irritated or superficially wounded, especially in those places which are comparatively free from clots.

§ 96. **Tumours of the Neck.**—Tumours of the neck vary considerably both as regards structure and size, and their removal may be attended with unusual difficulties. One often finds that a large tumour of the neck which appears to be still movable and easy to extirpate has deep and intimate attachments to the large vessels, including the common carotid artery and the internal jugular vein, and that injury to the displaced nerves, especially the vagus, the sympathetic, and the recurrent laryngeal, is only to be avoided by great care and exact knowledge of the anatomy. The extirpation of malignant tumours is the most difficult, because these are usually extensively adherent to the surrounding parts. I do not hesitate to class the extirpation of such tumours of the neck with the most difficult operations, and only experienced surgeons should undertake them when the tumours are large and adherent. One should inform himself as exactly as possible before every operation concerning the situation, extent, and mobility of the tumour, and one must at the same time determine whether dysphagia and dyspnœa, or hoarseness from pressure on the trachea, the larynx, or the recurrent laryngeal nerve, exist or not. When malignant tumours have become very extensive and firmly adherent they should no longer be operated upon. The skin incision in the neck is usually made longitudinally. One then works his way around the tumour with the finger or a blunt instrument and divides the stronger adhesions with scissors or the knife. Each bleeding vessel is immediately tied or caught above and below with an artery clamp before being divided. If it is found upon exposing the large vessels that the tumour is intimately attached to them, one will, if necessary, tie the vessel above and below and remove the intervening portion with the tumour.

Tumours of the neck—leaving out of account neoplasms of the thyroid gland—are divided into solid or cystic tumours. Solid tumours have their origin chiefly in the lymph glands. We will speak of these first, and in the same connection of enlarged scrofulous and tubercular glands, although we know that these are not considered as genuine tumours in the narrower use of the term.

I. **Tumours of the Lymph Glands.**—We mention first among tumors of the lymph glands scrofulous and tubercular lymphomata—that is,

chronic inflammatory hypertrophy of the lymph glands resulting from a scrofulous condition or from infection with tubercle bacilli that have entered the glands through the lymphatics that supply them. Tuberculosis of the lymph glands is sometimes a secondary affection following primary tubercular infection of the organism (Gussenbauer).

Scrofulous lymphomata are caused mainly by simple inflammatory hypertrophy of the lymph glands. In a tubercular lymphoma one always finds tubercles, in consequence of the entrance of tubercle bacilli. These tubercles run the course which is characteristic of tuberculosis—that is, they become caseous or suppurate, and lead to progressive infection of the neighbouring lymph glands. One consequently finds masses of tubercular lymph glands especially beneath the jaw, along the course of the large vessels, and in the supraclavicular fossa. These tubercular, suppurating, or caseous glands very often break through the skin and form fistulæ. The spontaneous cure of tubercular lymphomata is usually very slow—e. g., by calcification or after breaking through externally. As tubercular lymphomata of the neck lie in the region of the thoracic cavity, it is clear that they may easily give rise to further infection particularly of the mediastinal lymph glands, and that tuberculosis of the lungs or general tuberculosis may finally result. The latter seems, however, as a matter of fact, to occur only in exceptional cases. I nevertheless consider that the most careful and earliest possible removal of tubercular lymphomata of the neck is indicated. It can not always be determined before the operation whether one has to do with simple hypertrophy of the lymph glands or a tubercular lymphoma, or whether or not the latter has already undergone suppuration or become caseous. One frequently finds large tubercular abscesses of the lymphatic glands where one expected to find mere enlargement. At all events, in scrofulous individuals the operative removal even of glands that are the seat of simple hypertrophy is indicated if they plainly increase in size and if other neighbouring lymph glands of the neck likewise become infected or enlarged.

The best way to get rid of enlarged glands is to excise them completely. Simple division and scraping out of suppurating or caseous tubercular lymphomata is by no means so sure as regards recurrence as complete extirpation. Parenchymatous injections are also uncertain in their action, and are harmful in so far as the favourable time for a quick and complete recovery may be allowed to go by, as the mediastinal lymph glands may have already become infected.

The removal of enlarged glands, which is not always an easy matter, is best accomplished through a longitudinal incision. In enucle-

ating the gland one should keep close to its capsule and carefully separate the fibres of connective tissue here either with the finger or with curved scissors. A premature opening of suppurating or caseous glands is to be avoided as far as possible. If it should occur, the wound must be disinfected with special care by means of a 1-to-1,000 solution of bichloride during and after the operation, in order to insure primary union and to prevent local recurrence or general infection with tubercle bacilli. The latter has been sometimes observed after operations on tubercular foci. The more thorough the removal of tubercular lymphomata, the less frequently are recurrences observed, as is shown, for example, by the statistics of Grünfeld taken from Gussenbauer's clinic. According to earlier statistics, recurrences occurred in one quarter of the cases operated upon. The cases reported by Kritsch and Scheyer, in Fischer's clinic, gave results that were by no means favourable to extirpation. Recurrences are in part the result of reinfection when patients who have been cured return to their former unfavourable conditions of life.

After the glands have been removed and the wound has been irrigated with 1-to-1,000 bichloride solution the latter is drained at its lower angle and closed by suture. By the use of an antiseptic protective dressing, which includes the head and chest, primary union is usually obtained, even after extensive operations, in from six to eight or ten days. After scraping out suppurating glands with a sharp spoon, the best plan is to pack the wound with iodoform gauze. It may then, in suitable cases, be closed by secondary suture after removal of the packing. In every case of tubercular glands an anti-tubercular constitutional treatment is of the greatest importance (see Principles of Surgery, § 83).

Malignant Lymphoma (Hodgkin's Disease, Pseudo-leukæmia) is a progressive enlargement of lymph glands in connection with anomalies of the blood-forming organs. We are indebted particularly to Billroth and Winiwarter for valuable information concerning this disease. It usually begins with the appearance of nodular, soft swellings of considerable size in the lateral region of the neck (see Fig. 282). The tumour, which consists of several soft bunches of glands, is entirely painless and, as a rule, very movable. After a time the neighbouring lymph glands usually swell one after another, reaching, for instance, as far as the axilla on the involved side, then those of the other side participate, and finally the mediastinal and retroperitoneal lymph glands, etc., are often involved. Metastases in the internal organs (lungs, spleen, liver, kidneys, bones) are also sometimes observed. Histologically we have to do with a simple hypertrophy of the glandu-

lar substance. The course of the disease may cover years, and the general health of the patient often remains for a comparatively long time undisturbed. Death usually results from increasing anæmia and emaciation. A fatal termination sometimes occurs suddenly from asphyxia, as in goître, the result of softening of the cartilage of the larynx, or from bilateral paralysis of the vocal cords in consequence of pressure on the recurrent laryngeal nerve. The nature of the disease has as yet been but little investigated. The white blood-corpuscles are not increased in number, as in leukæmia, and hence the name pseudo-leukæmia. We have very probably to do with infectious influences which are as yet, at all events, unknown. Complications with leukæmia, with marked swelling of the spleen, do occur, however, as, for instance, in two cases which have recently come under my own observation. Children and young individuals in the twenties, in many cases apparently strong ones, are most frequently attacked.

Fig. 282.—Soft malignant lymphomata of the neck and both axillæ in a boy six years old.

Hodgkin's disease is best treated, according to Billroth, with arsenic given internally and in the form of parenchymatous injections. One begins, according to Billroth, by giving ten drops of Fowler's solution a day internally, and injecting daily into the enlarged glands two drops of the solution at first, and later from four to six drops. The internal dose is increased by two drops every third day till forty drops is reached, and the dose is then gradually diminished in the same way. If symptoms of poisoning appear, the dose must be diminished sooner. The results of arsenic treatment in cases of malignant lymphoma are sometimes surprising. The general health improves and the glands diminish rapidly in size. The disease is, at all events, often rendered less severe and held in check by the arsenic treatment. The treatment is frequently, on the other hand, without any effect. Operative removal of the enlarged glands never really accomplishes anything, as recurrence usually follows very quickly. They must, however, be removed in so far as they interfere with respiration.

Lymphosarcoma.—The different forms of sarcoma also occur in the lymph glands. They are usually smooth tumours of uniform consist-

ence, which have their location especially in the connective-tissue space inclosing the large vessels and beneath the lower jaw. Their growth is often very rapid, and they sometimes reach an enormous size (Fig. 283). The malignant forms soon break through the capsule of the gland and become adherent to the surroundings, especially to the vessels. The tumour not infrequently breaks through into the lumen of the vein and produces numerous metastases. After perforating the skin, ulcerating, sloughing tumours result, which may prove suddenly fatal from hæmorrhage, in consequence of erosion of the vessels. The duration of the disease before death ensues is seldom more than a year and a half. In other cases its course is more favourable, and if the tumour is promptly removed a complete cure is possible. It is an interesting fact, which Riedel also properly emphasizes, that inflammatory glandular hypertrophy sometimes changes very rapidly into sarcoma.

FIG. 283.—Lymphosarcoma of the right side of the neck in a man of fifty-eight with numerous metastases in the lung.

Carcinoma.—Carcinomata of the lymph glands of the neck are always secondary new growths—e. g., following primary carcinoma of the lip or the oral cavity. As the carcinoma is an epithelial growth, there can be no primary carcinoma of the lymph glands. Deep-seated epitheliomata of the neck have their origin in strayed epithelial germs, especially in fœtal remains of branchial arches (branchiogenic carcinomata), in strayed skin germs (dermoids), or in portions of the thyroid gland that have become separated. Deep-seated carcinomata of the neck that stand in relation to the thyroid gland are found especially between the œsophagus and the larynx, and they finally occasion corresponding difficulties in swallowing and breathing. The operative removal of such carcinomata is usually very difficult. Secondary carcinomata of the lymph glands are usually hard, nodular growths, which soon become adherent to the surrounding parts, break through externally, and then form sloughing, ulcerating tumours.

All deeply seated carcinomata come into relation, at a comparatively early period, with the large vessels, the pneumogastric nerve, the trachea, pharynx, and œsophagus, and their removal is usually very difficult. Gussenbauer recommends an incision which runs along the entire anterior border of the sterno-mastoid, and is crossed by a second incision from the middle of the chin to the centre of the sterno-mastoid or the acromial end of the clavicle. This forms the best exposure of the entire lateral region of the neck. Injury or division of

the pneumogastric on one side is of no great significance, but it has an injurious effect upon the innervation of the larynx (see page 527).

II. Other tumours of the neck are very numerous. Fibromata sometimes attain a very considerable size. They originate most frequently in the ligamentum nuchæ and in the fibrous tissue of the spinous and transverse processes of the cervical vertebræ.

Lipomata are found in different parts of the neck, but particularly posteriorly. Very enormous fatty tumours, weighing from ten to twenty kilogrammes, for instance, have been observed here which hung down from the nape of the neck to the back and over the shoulders. In addition to these circumscribed lipomata there also occur on the neck more diffuse fatty tumours of large size, which Madelung has recently described in detail (see Fig. 284). Very large pedunculated lipomata can be removed by a circular incision after encircling the tumour with rubber tubing.

The steatoma, a fatty tumour, which shines like mother-of-pearl, has been observed, according to Riedel, only twice.

In rare cases enchondromata and osteomata of the neck have been found. They are to be traced back to fœtal cartilaginous remains of the branchial arches, or they may have their origin in the vertebral column, the clavicle, or the first rib. So-called cervical ribs must not be confounded with osteomata. These are processes of bone of varying length, which, according to Gruber, are sometimes unattached, or arise from the first rib or the sternum, and are to be regarded as malformations. These cervical ribs may be the starting point for enchondromata and osteomata, and they sometimes require removal on account of pressure upon the subclavian artery and vein and upon the brachial plexus.

FIG. 284.—Diffuse lipoma of the neck (Madelung).

Neuromata, or neurofibromata in the form of circumscribed tumours, are rare, whereas multiple, plexiform neuromata, or, more correctly, neurofibromata, which are often complicated with marked

hypertrophy of the skin and the subcutaneous cellular tissue in the form of large diffuse tumours (elephantiasis), are more frequent (see Principles of Surgery, pages 760–762).

In such cases of extensive plexiform neurofibromata with elephantiasis of the neck the tumours may, if necessary, be reduced in size or wholly removed by excising wedge-shaped pieces at repeated sittings.

Sarcomata of the neck, aside from the lympho-sarcomata which have already been mentioned, have their origin mainly, as I have shown in detail, in the walls of the vessels and the fasciæ. Their course is essentially the same as that of lympho-sarcomata. It is of interest that cavernous tumours and blood cysts of the neck may finally undergo a sarcomatous degeneration. I recently had two cases of this sort.

Among non-malignant epithelial new growths, cutaneous horns occasionally appear upon the neck, and small, slowly growing adenomata, especially of the sweat glands.

Carcinomata of the neck are either superficial, ulcerating epitheliomata or deeply seated carcinomata, which leave the skin for a long time intact. The carcinomata that have their origin deep in the neck always develop, no doubt, as was mentioned on page 556, from fœtal epithelial germs—e. g., the remains of branchial arches (branchiogenic carcinomata, Volkmann, Gussenbauer)—from deep atheromata, or from strayed portions of the thyroid gland. These deeply seated carcinomata very soon become adherent with their surroundings, and lead, as a rule, to a speedy death from increasing marasmus, dysphagia, and dyspnœa (see page 556).

All tumours that stand in relation etiologically with the fœtal branchial canals, both cysts and solid tumours, are included under the name of "branchiogenic tumours."

Gussenbauer has recently described these more in detail.

Cystic Tumours of the neck occur in several forms.

Epithelial Cysts.—In this category belong the branchiogenic cysts which orginate in remnants of fœtal branchial arches, dermoids resulting from proliferation of scattered skin germs, and finally the cysts which arise from separated portions of the thyroid gland.

Branchiogenic cysts are in part thin-walled tumours with serous or sero-mucous contents (serous cysts, hydrocele of the neck) whose inner surface is covered with several layers of cylindrical epithelium. They vary greatly in size, sometimes reaching that of the fist or even that of a child's head. They occur on all parts of the neck where the congenital fistulæ are found, especially in the region of the hyoid bone, frequently, for example, between it and the mastoid process, at the

inner border of the sterno-mastoid muscle, and in the supraclavicular fossa, or near the upper end of the sternum. Branchiogenic cysts that have their location in the region of the hyoid bone may project into the floor of the mouth and resemble a ranula. Some cases of ranula are in fact cysts of this sort. It should be mentioned in this connection that other tumours also, with cartilaginous and bony framework, for instance, arise from the branchial canals or branchial arches (Weinlechner, Lannelongue, A. Grimm).

In addition to serous cysts of branchial origin there occurs a second form, which in its entire structure corresponds more to atheromata of the skin, and these cysts have therefore been designated as deep atheromata of the neck. The term "deep atheromata" is not strictly correct, as we have to do really with dermoid cysts—i. e., cystic tumours which have developed from embryonic involution of skin in the vicinity of the branchial clefts, a fact which Schnitzler also has of late properly emphasized. These deep atheromata, or, more correctly, these dermoid cysts, are usually small, being seldom larger than the fist (Fig. 285), and they grow very slowly. They usually consist of a thick, firm capsule of connective tissue with pavement epithelium and thick contents consisting of epithelial cells and cholesterin. The inner surface of genuine dermoid cysts has the structure of the skin. The contents consist of epidermic cells, hair, and sometimes also of cartilage, bone, and teeth.

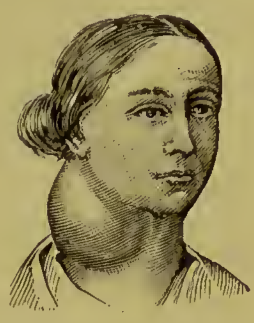


Fig. 285.—Deep dermoid cyst of the neck in a woman thirty-two years of age; cure.

It should finally be mentioned that epithelial cysts of the neck arise also from portions of the thyroid gland that have become separated.

Haeckel observed in the median line of the neck in the region of the hyoid bone a cyst of the ductus thyreoglossus (His)—i. e., the epithelial canal that grows downward from the anterior wall of the pharynx and represents the median anlage of the thyroid gland. Buds grow out from this duct on the neck which become differentiated into follicles; the duct itself disappears, only its commencement remaining permanently as the foramen cæcum of the tongue. Occasionally portions of this duct persist, and may give rise to ciliated cysts at the root of the tongue, on the hyoid bone, at the apex of the processus pyramidalis, or at the upper border of the isthmus of the thyroid gland. On the other hand, premature differentiation of the follicles of the thyroid gland may give rise to the accessory strumæ at the base of the tongue (see page 383).

The best treatment of all the congenital epithelial cysts that have been mentioned consists in their extirpation. Puncture with subsequent injection of tincture of iodine is by no means so reliable. In removing dermoid cysts and so-called deep atheromata, one must take special care that the sac is not ruptured and its greasy contents discharged into the wound. When the cyst has become adherent to the large vessels—e. g., the common carotid artery or the internal jugular vein—portions of its wall may be left if only the epithelial layer on the inner surface of the wall is removed.

Cystic Lymphangeioma.—Of other cysts of the neck which are not epithelial in character I mention, in the first place, the lymphangeiectasiæ, especially the congenital variety (congenital cystic lymphangeioma, congenital multilocular cystoid). The designation congenital cystic hygroma, at one time in use, has been properly given up as incorrect.

The congenital cystic lymphangeioma (Fig. 286) arises, as the name implies and as has been shown, especially by Köster, Wegner, Winiwarter, and others, from dilatation, new formation, and cystic degeneration of the lymph vessels. It is a lobulated tumour, consisting of numerous cysts, which is in some places firm in consistence and in others fluctuating. Its favourite location is the submaxillary region. It usually grows very rapidly, and may attain a considerable size, spreading over the face and the neck and into the thoracic cavity.

Fig. 286.—Congenital cystic lymphangeioma (Busch).

Less frequently analogous cystic lymphangeiectasiæ appear later in life.

The removal of a cystic lymphangeioma in children is only possible when the tumour is still small. Total extirpation of larger tumours is absolutely impossible, because the cysts penetrate in all directions the different tissues of the neck. It is therefore not surprising that it has not infrequently proved necessary to leave the extirpation uncompleted. In cases where removal is no longer possible, repeated incisions have been recommended, to bring about shrinkage of the cysts, and frequent injections of tincture of iodine, absolute alcohol, chloride of zinc, etc. Smith has secured very favourable results by drawing a silk thread through the tumour, leaving it for a few days, and removing it as soon as suppuration begins.

Blood cysts of the neck (Fig. 287) are very rare. As regards their origin, various forms may be distinguished. Some of these blood cysts

are malformations—that is, there is at one point on the involved vein a large unilocular or multilocular sac which is entirely shut off, or still communicates with the vein through a small opening. Sometimes, as in the case shown in Fig. 287, the vein that is involved is absent in part or altogether and the blood cyst is found in its place.

Fig. 287.—Blood cyst in a female child eighteen months old which developed from the right subclavian vein; the autopsy revealed absence of the subclavian vein (Koch).

In other cases we have to do with a varicose dilatation at one point in the wall of the vein, and the sac, filled with blood, either communicates with the mother vessel or it is completely shut off. In a third class of cases the cysts arise from cavernous angeiomata through the gradual coalescence of the cavernous spaces.

All blood cysts which remain in open communication with the veins—the internal jugular or subclavian vein, for example—have the characteristic that they can be more or less completely emptied by pressure, and that they increase and diminish in size during respiration.

Answering to their above-mentioned origin, blood cysts are in some cases congenital and in others they appear in later life. Their growth is usually slow. In the completely closed cysts, even, there is usually fluid blood of a dark or even black colour.

The best treatment of blood cysts is, no doubt, their extirpation when it is possible, with ligation of the vein, with which the cyst still communicates. I have three times successfully extirpated blood cysts of the neck. In case of completely closed cysts which can not be emptied by compression, puncture could be tried with subsequent injection of absolute alcohol or tincture of iodine.

In connection with blood cysts brief mention should also be made of angeiomata which appear upon the neck in their different forms—e. g., capillary angeiomata (telangiectasis), extensive varicose venous tumours, cavernous angeiomata, or arterial angeiomota (aneurysma racemosum or anastomoticum). For particulars concerning these and their treatment the reader is referred to Principles of Surgery, page 755.

Echinococcus Cysts.—Of parasitic cysts, the echinococcus cyst is sometimes found on the neck. It is always situated, according to Riedel, on the side and near the large vessels, and it is probable that the parasites gain access

with the blood to the smaller arteries and capillaries and here develop. The tumours always lie deep at first, then grow toward the surface, and may attain a large size, causing extensive destruction of tissue. Echinococcus cysts sometimes remain stationary for a long time and then suddenly begin to grow again.

The diagnosis of an echinococcus cyst is assured if the characteristic hooklets can be demonstrated by a trial puncture.

The treatment of an echinococcus cyst consists in a free incision of the sac and expulsion of the same through subsequent suppuration, which should be limited, as far as possible, by the use of antiseptic dressings. The connective-tissue sac can sometimes be removed at the time of operation.

Finally, bursal cysts should here be mentioned, the hygromata of the neck, although they do not belong properly to new growths.

Bursal hygromata of the neck are usually small tumours with serous contents. They seldom exceed the size of a nut and cause little or no discomfort. The mucous bursæ which most frequently occasion hygromata on the neck are the following: 1, the infrahyoid or thyrohyoid bursa between the hyoid bone and the notch in the upper border of the thyroid cartilage: 2, the suprahyoid bursa above the hyoid bone or upon its upper border; 3, the thyroid bursa on the median projection of the thyroid cartilage. In the region of the hyoid bone the suprahyoid gland also, according to Zuckerkandl, is the seat of analogous cystic growths. This small gland lies in the median line on the hyoid bone, or to one side upon the body of the same, and is probably, judging from its structure, a detached portion of the thyroid gland.

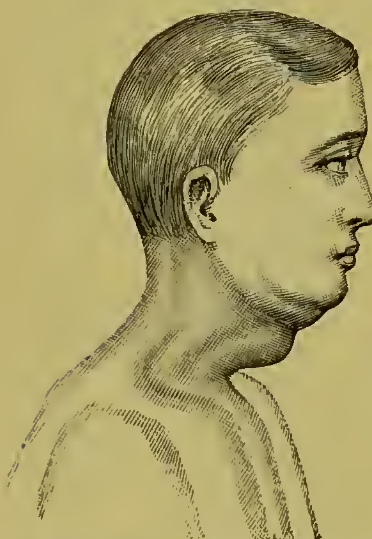


Fig. 288.—Median laryngocele in a young man of twenty (Madelung).

The treatment of hygromata consists in opening them and dissecting them out as completely as possible.

Air Tumours.—Cysts containing air sometimes occur on the neck, which may originate from the larynx, the trachea, or the lung. On the larynx, to one side of the thyrohyoid membrane, an air tumour the size of a nut, resulting from dilatation of the ventricle of the larynx, sometimes occurs. It may be unilateral or bilateral, and is an analogue of the air sacs that are found in the gorilla and the orang-outang. Madelung observed a median laryngocele (Fig. 288), resulting, probably, from an incomplete median fistula of the neck.

Congenital or acquired tracheal herniæ, or tracheoceles, are found over the trachea, resulting from congenital or acquired defects. Laryngoceles and tracheoceles have the character of herniæ—that is, they are due to a protrusion of the mucous membrane at a weakened place in their wall, owing to an increased expiratory pressure.

So-called herniæ of the lung appear upon the neck, mainly in consequence of dilatation of the emphysematous apices of the lungs, so that a tumour the size of a pear or an apple appears in the supraclavicular fossa

(Coekle, Morel-Lavallé). For a more detailed description of herniæ of the lungs, see § 115.

The subjective symptoms caused by these air tumours are usually slight. Their removal ought not, as a rule, to be very difficult, should the necessity arise.

§ 97. **Anatomy and Physiology of the Thyroid Gland.**—Before taking up the diseases of the thyroid gland we shall give a short review of its anatomy and physiology.

The thyroid gland is an epithelial gland without excretory duct, consisting of two lateral lobes united by an intermediate portion or isthmus. From the upper border of the isthmus there sometimes springs a middle lobe of variable size which extends upward, the so-called pyramid or middle horn. The isthmus usually lies in front of the second to the fourth tracheal cartilage. The two lateral lobes, or horns, extend upward on the right and left, adjacent to the large vessels, alongside the larynx as far as the hyoid bone sometimes, and posteriorly as far as the œsophagus.

The so-called accessory thyroid glands are of considerable practical significance. They are portions of gland tissue the size of a pea or bean, which have become separated from the main gland and are found in the region from the arch of the aorta to the hyoid bone. From these detached portions of the thyroid gland the so-called "accessory goîtres" arise, which develop, as Wölfler in particular has recently shown, toward the floor of the mouth in one direction and down into the bronchi in the other. R. Wolf and Bernays removed a tumour of the tongue and floor of the mouth which consisted of thyroid tissue. Deeply seated carcinomata of the neck may also have their origin in these accessory thyroid glands (Billroth, Madelung).

The thyroid gland lies between two layers of fascia which unite above and are attached to the cricoid cartilage. If one divides transversely the insertion of these layers of fascia the thyroid gland may be easily separated from the trachea in its duplicature of fascia, without hæmorrhage or injury, and pushed downward. This fact is of much importance in the performance of tracheotomy. The anterior surface of the gland is covered, besides, by the sterno-thyroid, the sterno-hyoid, the omo-hyoid, and the inner border of the sterno-mastoid muscles.

The thyroid gland is very vascular. It receives on each side a superior thyroid artery from the external carotid and an inferior thyroid artery from the thyroid axis, and finally an inconstant arteria thyreoidea ima, which is single and arises sometimes from the arch of the aorta and sometimes from the innominate. The very dense network of veins empties partly into the internal jugular and partly into the innominate vein.

In performing operations on goître an exact knowledge of the course of the recurrent laryngeal nerve is necessary. Injury to this nerve causes paralysis of the vocal cord on that side. It passes on the right side around the subclavian artery and on the left around the arch of the aorta, then ascends on the side of the trachea and the œsophagus, giving off numerous branches to both organs. It usually sends off, according to Drobnik, three or four branches, which enter, with the ramifications of the inferior thyroid artery, the tissue of the thyroid gland. These anastomose with the subdivi-

sions of the cardiac branch of the sympathetic. Their physiological significance is not clear. The recurrent laryngeal nerve is most likely to be injured in connection with ligation of the inferior thyroid artery. The relation of

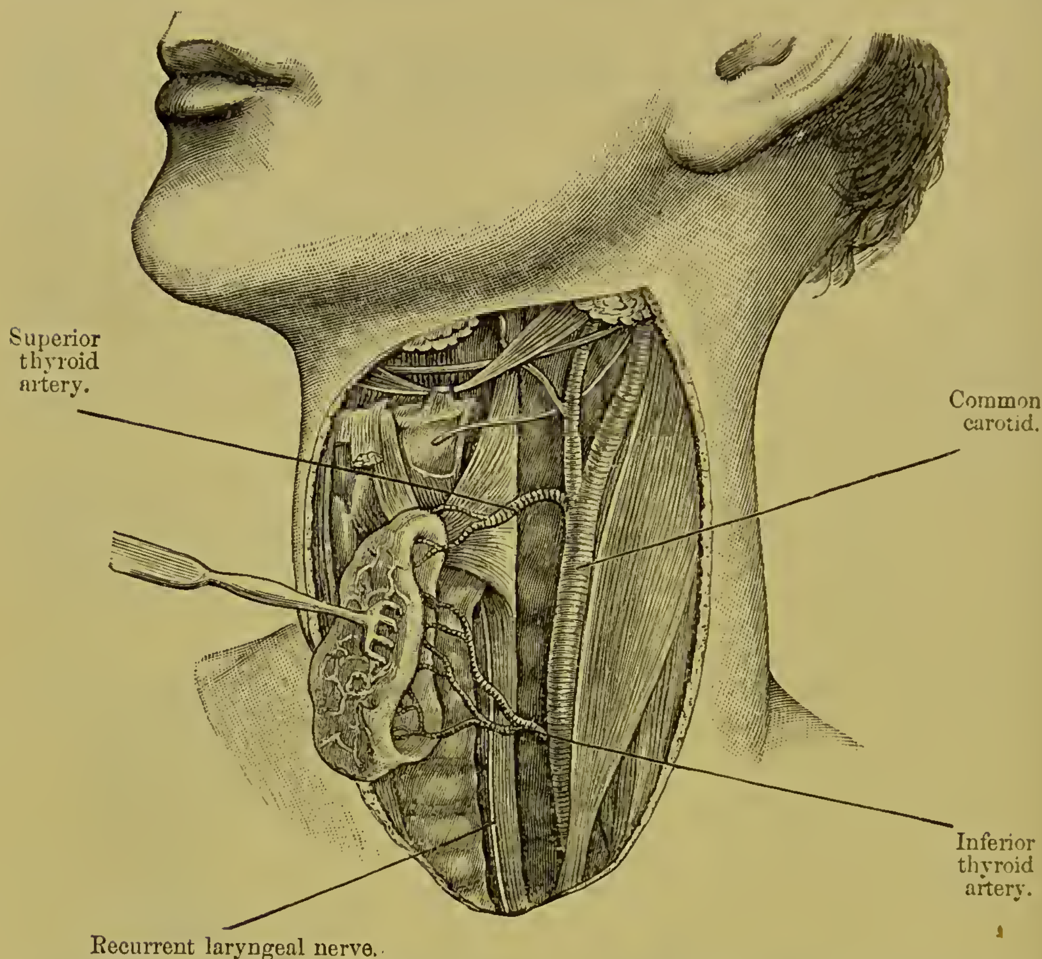


Fig. 289.—Relation of the recurrent laryngeal nerve to the inferior thyroid artery; the thyroid gland is retracted to one side (Wölfler); the nerve lies either in front of, between or behind the branches of the artery, or in front of or behind the main trunk.

this artery to the recurrent laryngeal nerve is by no means constant (Drobnik, Kocher, Rotter, Wölfler). The nerve lies either in front of or behind the trunk of the artery, or in front of, between, or behind its branches. It is most frequently found in front of or behind the two branches of the artery, near the point of bifurcation (Fig. 289).

The sympathetic nerve with numerous branches, and the middle cervical ganglion, are in relation with the trunk of the inferior thyroid artery (see Fig. 290). In order to avoid injury to the sympathetic nerve in ligation of this artery, Drobnik advises ligation of the thyroid axis. The cardiac branch of the sympathetic nerve has numerous connections with the recurrent laryngeal nerve.

For our knowledge of the structure and development of the thyroid gland we are especially indebted to the careful investigations of Wölfler (Ueber die Entwickelung und den Bau der Schilddrüse, etc., Berlin, G. Reimer, 1880).

Unfortunately, we have not space here to take up these questions in detail. In the fully developed gland a cortical and a medullary substance are distinguished. The gland usually diminishes in size in later life, and the gland vesicles very often degenerate. The size of the gland is very variable. Its average weight is from about thirty to seventy grammes. It is generally larger in infants than in adults, and it is also larger, as a rule, in women than in men.

The most important pathological change consists in an enlargement of the whole or a part of the gland, which is called goître or struma.

The function of the thyroid gland is still obscure. It probably stands in some relation to the spleen, regulates the blood supply of the head, especially

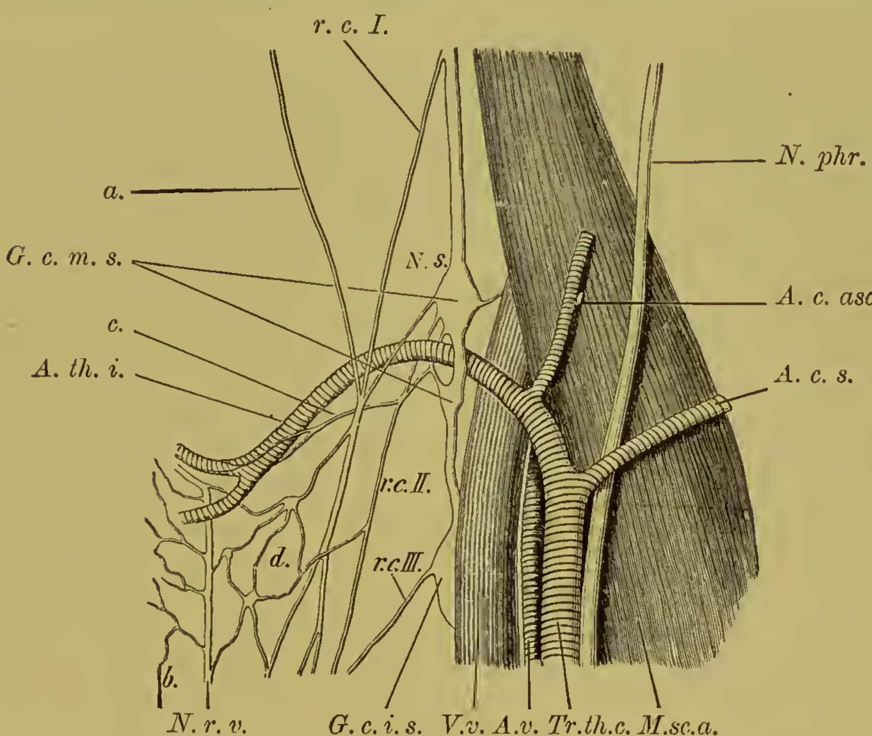


FIG. 290.—Relation of the cervical sympathetic and its branches to the inferior thyroid artery, and the recurrent laryngeal nerve with reference to ligation of the inferior thyroid (Drobnik).

M. sc. a. Scalenus anticus muscle.
N. phr. Phrenic nerve.
V. v. Vertebral vein.
A. v. Vertebral artery.
Tr. th. c. Thyro-cervical axis.
A. c. asc. Ascending cervical artery.
A. c. s. Superficial cervical artery.
A. th. i. Inferior thyroid artery.
N. s. Sympathetic nerve.
G. c. m. s. Middle cervical ganglion.
G. c. i. s. Inferior cervical ganglion.
r. c. I. First cardiac branch.
r. c. II. Second cardiac branch.
r. c. III. Third cardiac branch.
N. r. v. Recurrent laryngeal nerve.
a. Communicating branch of the first cardiac with the external branch of the superior laryngeal.
b. Pretracheal branch of the sympathetic.
c. Nerve filament accompanying the inferior thyroid artery.
d. Nerve plexus between the cardiac branches of the sympathetic and the recurrent laryngeal.

the brain, and has important secretory properties, assisting above all in the chemical composition of the blood. Complete removal of the gland causes, as Horsley and others also showed by experiments upon animals (monkeys), an accumulation of mucin in the body (myxœdema), together with anomalies in nutrition, and peculiar cerebral disturbances, especially idiocy and cretin-

ism (Kocher). Myxœdema, and particularly idiocy and cretinism, have also been observed in goître as the result of extensive parenchymatous degeneration. One important function of the thyroid gland is probably to prevent the accumulation of mucin in the body or to convert mucigenous substances into those that are harmless (see page 578, Myxœdema and Cachexia Thyreopriva).

One observes, after complete removal of the thyroid gland in man, a peculiar cachexia which has a chronic course—so-called cachexia thyreopriva (Kocher), or myxœdema. It usually results fatally in a few years. Tetany is also occasionally observed after complete extirpation of the gland (see particulars concerning cachexia thyreopriva, myxœdema, and tetany, pages 578, 579). Removal of the entire gland in man is therefore altogether inadmissible.

The enlargement of the thyroid gland, with palpitation of the heart and exophthalmos, in connection with exophthalmic goître (Basedow's disease), is very striking. This affection probably depends upon a simultaneous irritation of the accelerator nerves of the heart, of the sympathetic fibres which supply the unstriped muscular fibres in the back part of the orbit and in the lids, and of the inhibitory fibres of the vessels of the thyroid gland. Basedow's disease may be due to an intoxication of the system from morbid activity of the thyroid gland. Permanent cure has been repeatedly observed after the removal of the part of the gland that has undergone goîtrous degeneration. According to R. Stierlin, of twenty-nine cases thus far reported, twenty-two were very much improved by extirpation of the goître. According to Determayer, among thirty cases in which thyroidectomy was performed, no result was observed in three cases, while in the other twenty-six improvement or recovery followed. According to Freiberg, among thirty-one cases of genuine Basedow's disease, sixteen were cured by thyroidectomy. Krönlein saw considerable improvement result in eight cases from thyroidectomy. Of the characteristic symptoms of the disease that were cured or improved by the operation were the tachycardia, the tremor, the psychic excitability, the insomnia, and of course the goître. The exophthalmos, on the other hand, was not improved. Marked improvement or complete recovery has also been secured by ligation of the arteries supplying the gland and by removing a portion of the hypertrophic inferior turbinated bone. At all events, the surgical treatment of exophthalmic goître deserves most careful consideration.

One should, however, study each case by itself, since it can not be said with certainty at the present time that thyroidectomy is adapted to every case. The operative treatment should serve merely to remedy the threatening symptoms due to the presence of the thyroid tumour, while our principal therapeutic measures are dietetic and hygienic. (For thyroid feeding see page 576.) In determining the indications for an operation in Basedow's disease, the possibility of a condition designated by Paltauf "status thymicus" should be taken into consideration. This is characterized by persistence or hyperplasia of the thymus gland, enlargement of the lymphoid structures (lymph glands, tonsils, lymph follicles of the intestine and tongue, and the spleen), by a red medulla in the long, hollow bones, smallness of the arterial system, dilatation of the heart, and thinning of the blood. This status thym-

icus causes a diminution in the resisting power of the body, and many cases of sudden death may be traced to it.

§ 98. **Diseases of the Thyroid Gland.**—We have already spoken briefly of injuries of the thyroid gland in § 88. Hæmorrhage and arrest of the same in accordance with general rules are here of chief importance.

Acute inflammation of the thyroid gland, acute thyroiditis—apart from that which follows injuries—occurs rarely in the healthy gland. Inflammation of an enlarged gland, or strumitis, is more frequent (see page 574). Idiopathic, non-traumatic inflammation is, generally speaking, metastatic, resulting from infection by microbes which have reached the gland by means of the circulation from some focus of disease. It occurs in the majority of cases as a complication of some infectious disease—e. g., pyæmia, septicæmia, erysipelas, diphtheria, acute articular rheumatism, acute exanthemata, puerperal infection, typhoid fever, or other infectious diseases of the gastro-intestinal tract (dysentery, cholera), etc. In other cases it is to be explained as an inflammation in continuity—that is, it results from the spreading of a lymphangitis or lymphadenitis. We are especially indebted to Kocher and Tavel for their investigations concerning the etiology of acute strumitis. Kocher was the first to emphasize the fact that this affection may arise from the entrance of microbes from the digestive tract. Tavel and Brunner, in fact, found the *Bacillus coli communis* in acute suppurative strumitis. This is one of the most common of the microbes that are found in the intestinal canal. Temporary enlargement of the thyroid gland frequently occurs during menstruation and in lying-in women. Acute inflammation is characterized by painful swelling of the gland, and it often goes on to suppuration or the formation of gangrenous areas, with a breaking through and burrowing of pus in the surrounding tissues. A fatal termination may follow from general intoxication, from pyæmia or sepsis, from suppurative mediastinitis, from the discharge of pus into the trachea, etc.

The treatment of acute inflammation of the thyroid gland is at first antiphlogistic (ice, etc.). In case of suppuration, one must at the earliest moment make an incision for the discharge of the pus and treat the wound antiseptically. In case of deeply seated abscesses which are not easily accessible, aspiration of the pus with subsequent injection of carbolic acid is to be recommended (Kocher). Patients suffering from acute inflammation of the gland must always be carefully watched, so that tracheotomy may be promptly performed in case of danger from suffocation.

Among pathological changes in the thyroid gland, its hypertrophy—so-called goître or struma—is especially important.

Goître.—Goître, which is to be regarded not as a local but as a constitutional affection, is due in by far the larger number of cases to hypertrophy of the epithelial elements—in other words, it is an adenoma. These adenomatous or follicular goîtres very often undergo subsequent retrogressive changes, usually in the form of a cystic or colloïd (gelatinous) degeneration. In other cases the hypertrophy affects particularly the connective tissue or the vessels. Three principal forms of goître may thus be distinguished: (1) adenomatous or follicular (epithelial) goître, (2) fibrous goître, and (3) vascular goître. Between these single varieties there are numerous transition forms.

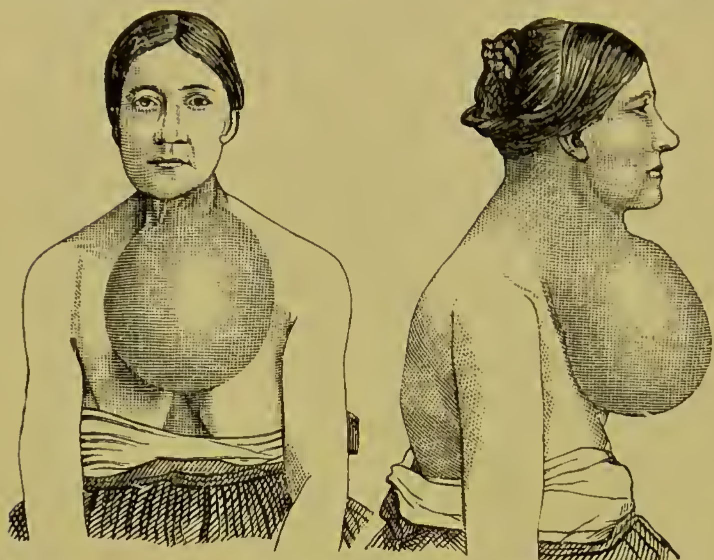


Fig. 291.—Cystic goître in a woman forty years of age; extirpation; recovery (Kocher).

From a clinical and anatomical standpoint we distinguish further benign and malignant goîtres. The latter are the carcinoma and the sarcoma.

The size of goîtres varies all the way from a circumscribed or more diffuse, easily recognisable fulness of the neck to a large tumour, such as is represented, for example, in Fig. 291.

Goître is sometimes congenital.

We are especially indebted to Wölfler for his very thorough account—fuller than any that we before possessed—of the development and structure of goître, and more recently to Hitzig in particular.

Benign goîtres are, according to Wölfler, in part simple hypertrophies and in part adenomata. The hypertrophy results, according to the same authority, from an increase in the number and size of the normal vesicles, just as in normal growth. The adenoma, on the other hand, is an epithelial new growth which is developed from embryonic, abnormally vascularized glandular tissue, and it either remains such or is transformed into tissue that has a normal appearance. These adenomata sometimes reach a large size. They are apparently non-malignant, but may form metastases and frequently recur. In addition to these, Wölfler also describes fœtal adenomata, which contain almost exclusively small spherical and oval clusters of cells and solid columns of cells. They consist of unorganized embryonic cell material which, in the further growth of the tumours, passes through all those

changes that are observed in the development of the embryonic thyroid gland.

The pure hypertrophy described by Wölfler and the two principal forms of adenomata are generally classed together, after Virchow, as struma hyperplastica follicularis seu parenchymatosa.

Simple hypertrophy and adenomata may form circumscribed nodules or involve a lobe or the entire thyroid gland. This distinction, briefly expressed as one between diffuse and nodular hypertrophy, is of considerable importance from a clinical and therapeutic point of view, whether we have to do with a pure hypertrophy in Wölfler's sense or with adenomata.

In rare cases, congenital enlargements of the thyroid gland in its whole circumference have been observed in infants (Fig. 292, after Kaufmann). B. Credé saw a goître of this sort in a boy fourteen years old.

Very frequently a large amount of colloid is formed in the interior of the vesicles, giving rise to a colloid goître. The extent of this colloid transformation is very variable. In the most marked cases enlarged vesicles are found which are only separated from one another by thin partitions of connective tissue. There are almost always vesicles present, however, that are still free from colloid and solid clusters of cells (Wölfler's interlobular adenoma). Wölfler distinguishes two forms of colloid goître: (1) As the more frequent form, this interlobular adenoma that has just been mentioned, and (2) the cysto-adenoma, with the formation of large cystlike cavities, whose contents consist partly of colloid and partly of an albuminous fluid, with cells that have undergone fatty degeneration and become desquamated. Cysto-adenomata are again divided, according to Wölfler, into two forms: the interlobular cysto-adenoma, which is characterized by the new formation of round epithelial cells in the interlobular spaces between the cysts; and the papillary cysto-adenoma, which arises in the interlobular tissue from proliferation of the lining epithelium of the vesicles and from new growth of connective tissue.

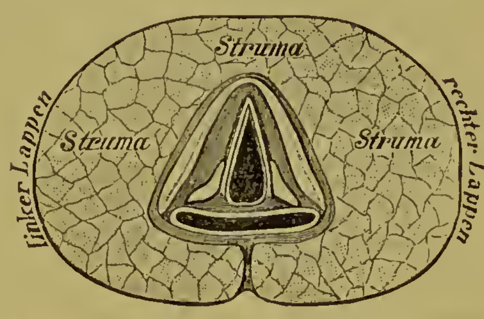


FIG. 292.—Congenital circular enlargement of the thyroid gland in an infant.

Wölfler's myxomatous adenoma consists of a reticulum which is hyaline and structureless and which often undergoes more or less fibrous degeneration, appears indurated or calcified, and is permeated with scattered clusters of gland cells of different size.

The other most important forms are the vascular and the fibrous goître.

Vascular goître (struma vasculosa) is characterized by proliferation of the vessels, either capillaries, veins, or arteries. Such a goître has frequently the appearance of a telangeiectasis or cavernous angeioma. Cysts may arise later from hæmorrhages and subsequent necrosis.

Proliferation of the connective tissue may take place, likewise resulting from hæmorrhages and softening of the tissue, and a fibrous goître is thus formed (struma fibrosa). Hyaline degeneration of this form of struma not infrequently follows. Calcification is sometimes observed, and in rare cases

ossification (Lücke). Amyloid degeneration affects the vessels chiefly, but a local amyloid growth is sometimes found, resulting in the formation of waxy nodules (amyloid goître).

The above-described changes are combined in goîtrous tumours in many different ways, and the appearance of goîtres on section is therefore often very varied.

The condition of the capsule is of especial importance, particularly in connection with the operative treatment of goître. A distinction is to be made in the first place between the capsule of the gland proper and the fascial covering of the goître. It is also important to know that, by atrophy of the muscles of the neck and the gland tissue of the cortical substance, numerous layers of connective tissue are formed which are to be regarded as capsules of the goître.

Of malignant tumours of the thyroid gland, the malignant adenoma is first to be mentioned, which resembles the benign form in its structure, but in its growth and course shows a decidedly malignant character. It is usually a transition form between adenoma and carcinoma.

Carcinomata appear in the thyroid gland, according to Wölfler, in three forms: (1) Alveolar carcinoma (scirrhus, medullary carcinoma), (2) epithelioma with cylindrical cells, and (3) epithelioma with pavement cells. The origin of the last form is explained, perhaps, by supposing that in connection with the normal closure of the branchial arches portions of the epidermis are included within the gland at the same time (branchiogenic carcinoma of the thyroid gland).

The sarcoma, like the carcinoma, is most likely to develop when a goître already exists. The various forms of sarcoma have been found in the thyroid gland, especially round-celled, spindle-celled, giant-celled sarcomata, angeiosarcomata with striated muscular fibres (Wölfler), and alveolar sarcomata. They are mostly nodular tumours, which usually involve only a portion, rarely the whole, of the thyroid gland.

From the microscopic examination of the metastases one can draw no conclusion as to the structure of the primary tumour, which, as we stated above, may vary considerably.

Tuberculosis of the thyroid gland seems, according to Wölfler, to occur only secondarily and to be comparatively rare. P. Bruns has given a detailed description of tuberculosis of the thyroid gland, basing his observations on a tubercular goître that came under his own observation. It is most commonly observed in general miliary tuberculosis as miliary tuberculosis of the thyroid gland (Cohnheim, E. Fränkel, Weigert). The second form, with the formation of large tubercular nodules or caseous foci (Virchow, Chiari, F. Fränkel, P. Bruns), is much less frequent. It is always a secondary affection. Primary tuberculosis of the thyroid gland has thus far been described only in one (doubtful) case by Weigert. Gummata of the thyroid gland—i. e., syphilitic goîtres—have been repeatedly observed.

Echinococcus cysts of the thyroid gland are of rare occurrence. According to Zoege-Manteuffel, eight cases are to be found in literature. Of these patients, three died from perforation of the trachea. In most of these cases the correct diagnosis could not be made.

As has been mentioned, accessory goître is developed independently of

the thyroid gland in detached portions of it. It is either not connected with the gland at all or only by means of the vessels or connective tissue. These accessory thyroid glands sometimes become the seat of carcinomata, sarcomata, and other tumours, as has already been stated (see above, page 556).

But little light has as yet been thrown upon the etiology of simple goître. We only know that the disease is associated with certain localities. In level districts it is rare. It is especially common in Switzerland and the Tyrol, where there are valleys in which inhabitants free from goître are the exception. The cause of the affection has been sought in some special peculiarity of the soil or the drinking water. The presence of magnesite in the former or the lack of iodine in the latter has been supposed to be the exciting cause of the disease. Goître is endemic, according to Bircher and Kocher, in a certain district of the canton of Berne, while the regions where Jura lime is found may be designated in general as free from the disease. Vegetable pollution of the soil seems, according to Kocher, particularly to favour the development of the disease by changing the quality of the drinking water. This explains the fact that in districts where goître is endemic certain springs are designated as "goître springs" and others as "antigoître springs." Certain families which get their drinking water from so-called antigoître springs are not afflicted with the disease. Tavel found in non-goîtrous waters exceptionally few micro-organisms. If goître-producing water is injected into rabbits, swelling of the thyroid gland takes place.

The air and social conditions have also been held responsible for the disease. It is of interest that in those districts especially where goître is endemic, epidemics of the disease sometimes occur—e. g., in garrisons and boarding schools—which develop in a very acute form, and may then disappear just as quickly.

An important predisposing cause of the disease may be looked for in all those conditions which lead to temporary or more permanent enlargement of the thyroid gland as the result of increased afflux or diminished efflux of blood. In this way especially mountain-climbing, the carrying of heavy burdens, frequent shouting, pregnancy, diseases of the heart and lungs, infectious influences, etc., have their effect. Exophthalmic goître (see page 556) is also mainly the result of congestive hyperæmia due to a peculiar vascular neurosis, probably of the sympathetic. Struma in goître districts is much more frequent among women than among men. One often finds a swelling of the thyroid gland in young girls at the age of puberty.

Goître seems also to be hereditary, and to be transmitted usually by the mother.

The final cause of goître is probably a miasma, which perhaps produces its effect by means of micro-organisms that enter the organism chiefly with the water that is drunk and produce, above all, hyperæmic conditions in the thyroid gland. No particular microbe, however, has as yet been proved to be the cause of the affection.

Deaf-mutism and idiocy (cretinism) also occur frequently in goître districts. They are observed either by themselves or combined with goître. Endemic cretinism and goître are no doubt to be traced to similar causes (see also page 578). Goître is in general to be regarded not as a local but as a constitutional disease.

Fig. 293.—Marked compression and membranous softening of the trachea in the vicinity of the fourth upper tracheal cartilage due to pressure of a goitre; the trachea is dilated below the stenosis (Demme).

The symptoms and the course of a struma depend, naturally, upon its size, and partly upon its anatomical structure.

The subjective symptoms are caused chiefly by pressure upon the neighbouring organs, especially upon the vessels, the nerves, the trachea, and the œsophagus.

Owing to pressure upon the vessels, especially upon the internal jugular vein, symptoms of congestion of the vessels of the head result which, in case of large goîtres, may become extreme as soon as the patient makes any exertion. In general, however, the large vessels escape pressure in part by being displaced to one side.

Disturbances of the heart's action and the innervation of the larynx may ensue from pressure upon the pneumogastric and recurrent laryngeal nerves, especially in those cases in which the goître has grown downward behind the sternum. Increase in the frequency of the heart contractions may result from pressure upon both pneumogastric nerves. Pressure on the recurrent laryngeal nerve causes, not infrequently, unilateral or bilateral paralysis of the muscles of the larynx. The recurrent laryngeal nerve, as is well known, supplies all the muscles of the larynx with the exception of the crico-thyroid, which is supplied by the superior laryngeal. Life is chiefly endangered by paralysis of the dilator of the glottis, the posterior crico-arytenoid muscle. Unilateral paralysis of this muscle causes dyspnœa; bilateral paralysis, immediate asphyxia from closure of the glottis (see also § 105, page 614).

Other functional changes resulting from pressure upon the recurrent laryngeal nerve are disturbances of speech (hoarseness, aphonia, etc.).

The respiratory disturbances ("goître asthma") depend in part upon this compression of the recurrent laryngeal nerve, and especially upon pressure on the trachea. The latter is narrowed by pressure and undergoes membranous softening (Fig. 293). The trachea is often pushed to one side and constricted by a unilateral goître, sometimes to such a degree as is represented in Fig. 294. In other cases it is compressed from two or from three sides or from in front against the vertebral column. This pressure is particularly dangerous in case of a goître behind the sternum, which, being crowded in between the sternum and the vertebral column, presses the trachea and the œsophagus against the latter. Death then frequently ensues from acute asphyxia, due, perhaps, to inflammatory swelling, or from gradually increasing, chronic carbonic-acid poisoning. In rare instances a goître grows in behind the trachea, as, for example, in the case of struma intrathoracica retrotrachealis observed by Krönlein, which is represented in Fig. 295.

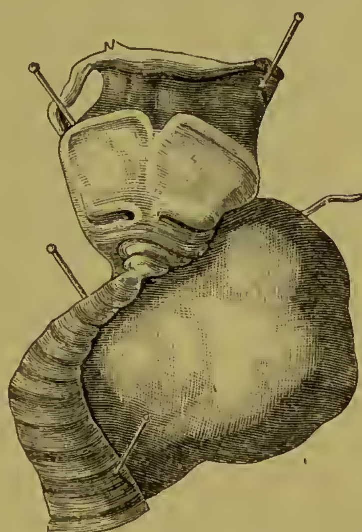


Fig. 294.—Lateral displacement of the trachea brought about by a goître (Lücke).

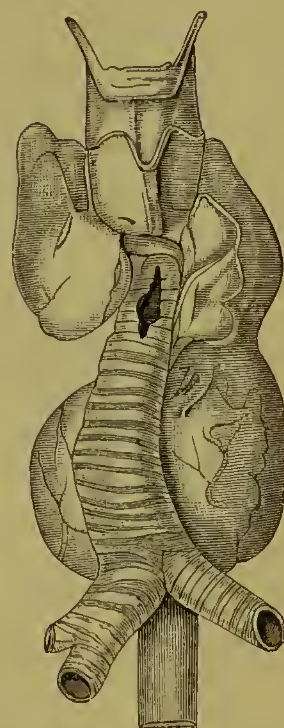


Fig. 295.—Intrathoracic and retrotracheal goître (Krönlein).

The tracheal rings, as was said above, may disappear, to a greater or less degree, from atrophy and fatty degeneration in consequence of continued pressure upon the trachea, so that, as Rose in particular has stated, the rigid cartilaginous tube may become a more or less membranous one. Such patients may die suddenly from asphyxia when the position of the head is changed in their sleep or during chloroform anæsthesia. Asphyxia is conditioned in these cases upon a sudden stenosis of the softened trachea. I believe with Krönlein that death from goître is in the great majority of cases due to asphyxia caused by a sudden increase in the pressure of the goître against the softened

tracheal wall resulting in a complete occlusion of the already narrowed lumen of the trachea. Death is usually preceded by acute attacks of suffocation, which occur especially during the night. This increase in the pressure exerted by the goître may be caused by a displacement of the latter, resulting in incarceration, or by an involuntary forcible change in the breathing mechanism due to an uncomfortable position in bed, or to an accumulation of mucus in the trachea during sleep, etc. This forced breathing brings into action the accessory muscles of respiration (sterno-hyoid and sterno-thyroid), and the greater the dyspnœa the stronger the contraction of these muscles, and hence the more energetic the compression of the trachea (Krönlein). This explains the hypertrophy of these muscles in chronic dyspnœa from goître. In other cases death from goître results more from disturbed heart action and from interference with respiration due to other causes, such as pressure of the tumour upon the pneumogastric and recurrent laryngeal nerves (paralysis of the vocal cords, Wölfler, Krause, and others).

Dysphagia in consequence of compression of the œsophagus occurs only exceptionally, and is most common in those rare cases of retropharyngeal or retrotracheal goître, which may also develop from aberrant lobules of the thyroid gland. Cases of this kind have been observed by Czerny, Kocher, Wölfler, and Krönlein (Fig. 295). Difficulties in swallowing are most common in malignant goîtres.

The further course of the disease is variable. The goître sometimes grows more and sometimes less rapidly. It not infrequently remains stationary, or diminishes in consequence of the above-described forms of degeneration. Finally, it is important to note that some goîtres develop very acutely and disappear just as suddenly.

The so-called "wandering goître" (Wölfler) is of special clinical interest. These goîtres are movable to an extraordinary degree; they lie now in their normal place—e. g., in the vicinity of the first tracheal rings—and again are drawn down during inspiration behind the sternum or behind the right clavicle into the right or left mediastinum and then occasion attacks of suffocation and disturbances in the circulation from pressure upon the trachea and the large vessels. In such cases there is sometimes also striking mobility of the trachea and the larynx in a direction from above downward (Wölfler). Wölfler distinguishes this wandering goître from the so-called *goître plongeant* which is situated behind the sternum and the clavicle, and, as a result of its own mobility, is drawn deeper down during inspiration and appears again during expiration.

Acute inflammation in a goître (acute strumitis) sometimes occurs, and is mainly metastatic, being due to infection by microbes which are

carried to the gland by way of the circulation from some focus or in the course of some infectious disease. There is acute swelling of the goître with hyperæmia of the skin, or, it may be, suppuration and sloughing. The interference with respiration which acute strumitis brings about may be of an alarming character.

Injuries to goîtres are especially to be feared on account of hæmorrhage. Extensive suppuration may also result from open wounds.

Malignant tumours, such as malignant adenoma, carcinoma, and sarcoma, seldom develop in the normal thyroid gland, but, with few exceptions, only when it is the seat of a goître. Hinterstoisser made a careful examination of fifty cases of carcinoma of the thyroid gland and found that the medullary carcinoma was the most frequent, then the adeno-carcinoma, and finally the scirrhus, which was the least frequent. The malignant tumours soon become adherent to the adjacent parts, increase rapidly in size, and cause secondary tumours in the neighbouring glands and metastases in the internal organs (Fig. 296) and in the bones. The metastases in carcinoma of the thyroid gland are not carried, as ordinarily, by way of the lymph channels, but, as in sarcoma, mainly by means of the blood-vessels, which are more frequently perforated. The metastases in the bones grow slowly, resemble microscopically the primary tumours or the normal tissue of the thyroid gland, often remain solitary, and should therefore be extirpated in case, for example, of metastatic adenomata. Such metastases in the bone may perform the normal functions of the absent thyroid gland, as in a case observed by Eiselsberg. Sudden, rapid growth of a goître in a person beyond middle life and the appearance of adhesions, secondary tumours, or metastases, are therefore strong indications of the development of a malignant tumour. In consequence of adhesions and secondary tumours in the glands of the immediate neighbourhood, difficulties in swallowing are also usually observed in addition to the respiratory disturbances. This symptom is, as we have seen, less common in non-malignant goîtres.

Fig. 296.—Carcinoma of the thyroid gland in a man of fifty: *a*, primary tumour; *b*, secondary tumours of the glands; *c*, secondary tumour of the clavicle; *d*, secondary tumour of the scapula (Lücke.)

Primary as well as metastatic malignant new growths in an otherwise normal thyroid gland are, as has been said, less frequent. We

have already mentioned (pages 556 and 562) that deeply seated malignant tumours of the neck, carcinomata particularly, may originate in accessory thyroid glands. In the metastases of malignant goîtrous tumours the structure of the normal thyroid gland is occasionally in part reproduced (J. Kramer).

§ 99. **The Treatment of Goître** depends in part upon its character, and one should therefore in each case inform himself carefully as to the probable structure of the tumour.

The treatment of simple goître is partly medical, but the most effectual is the operative.

In the earliest stages of goître, especially the parenchymatous (follicular) form, the administration of iodine internally is sometimes beneficial if continued for weeks or months. It is best to give one or two drops of pure tincture of iodine in water daily. The iodide of potassium is by no means so sure. I have never seen favourable results from the external application of tincture of iodine. Temporary diminution may also be secured by the application of cold by means of an ice coil.

The administration of fresh raw thyroid glands of sheep or calves (one or two a week or two to five grammes a day aseptically prepared, chopped fine, and spread on bread with salt and pepper) or the administration of thyroid-gland tablets are far preferable to the iodine preparations taken internally. By these means goîtres may be diminished in size very materially, and even made to disappear altogether (Bruns, Reinhold, author).

In parenchymatous goître injections of from a half to one gramme of tincture of iodine (Lücke) or absolute alcohol (Schwalbe) have been frequently recommended. I formerly preferred to use a mixture of tincture of iodine and absolute alcohol in equal parts. Mosetig-Moorhof speaks highly of the effect of a mixture of one part iodoform, five parts ether, and nine parts olive oil, or iodoform one gramme to ether and olive oil each seven grammes. Injections of from one to four grammes of the solution are made at intervals of from three to eight days.

These injections must be made under aseptic precautions, in order that suppuration may be avoided, and the patient should lie down at the time, as fainting attacks frequently occur. After disinfecting the field of operation with ether and 1-to-1,000 bichloride, the aseptic needle of an empty sterilized hypodermic syringe is introduced perpendicularly into the goître. The vessels that are visible from the outside are avoided of course, as well as the places where the large vessels of the neck and the vessels of the thyroid gland are located. One convinces himself whether or not the needle has entered a blood-vessel by drawing the piston of the syringe. If blood is aspirated, another place must be chosen. If cystic fluid is drawn, one removes as much of it as possible and then injects half a syringe of pure tincture of iodine or a syringeful of tincture of iodine and absolute alcohol in equal parts. The injections are continued for a long time at intervals of several days, a new place for making the puncture being selected each time. In cases of substernal goître one can sometimes facilitate the injections by making the patient cough. After the injection the puncture opening is closed with iodo-

form collodion if necessary. If there is much reaction, ice is applied and the patient is kept in bed. The injections may result in diminution in the size of the goître or in complete recovery. Success sometimes results from the treatment very quickly, and sometimes only after a longer period.

Injections are usually without effect in all cases of colloid and fibrous goître. They are especially adapted to the parenchymatous or follicular form of the disease. These injections, which are not so free from danger as many believe, are now less generally used than was at one time the case. Such excellent results are now secured by operation that Wölfler is quite right in saying that surgeons of the present time have more confidence in using their knife and their fingers than in working in the dark with the point of a hypodermic needle.

Evacuation of the cysts by puncture, followed by the injection of iodine to bring about obliteration of the same, is much less frequently resorted to than formerly. Superficial cysts with smooth, thin walls are especially suited for this treatment. The puncture is made with a stout hollow needle and the contents, a viscous fluid usually, are then aspirated by means of an aspirator or a small syringe. This slight operation also must be performed under antiseptic precautions and with great care to avoid the entrance of air. Otherwise the technique is essentially the same as that of the parenchymatous injections that have just been described.

Larger cysts which are not too deeply situated may be opened under local anæsthesia (cocaine) or in narcosis, packed with iodoform gauze, and allowed to heal by granulation.

The surest method is, of course, extirpation of the goître or thyroidectomy.

The technique of thyroidectomy has of late been greatly improved, thanks to the labours of Kocher, Socin, Roux, Wölfler, and others. Kocher had but six fatal results from his last two hundred and fifty cases. Roux (Lausanne) lost but two patients out of one hundred and thirteen who were operated upon for goître. The mortality, which formerly reached thirty to forty per cent, has now been reduced to from one and three tenths to two per cent—a brilliant triumph, surely, of our surgical technique.

Sudden death following operation for goître may be caused, aside from accessory injuries and different complications, by the so-called status thymicus (Paltauff) which is described on page 566.

Sick, Horsley, Socin, Juillard, and particularly Reverdin and Kocher, were the first to discover that after total extirpation of the thyroid gland a peculiar cachexia appears which Reverdin first designated as operative myxœdema, Kocher as cachexia strumipriva or cachexia thyreopriva. This cachexia is caused by loss of the thyroid gland and may terminate fatally. Horsley observed essentially the same disturbances in the monkey after extirpation of the gland. Tetany, which is noticed especially in animals (cats) after complete removal of the gland, is

closely related with this chronic cachexia or myxœdema. It usually terminates fatally in a few days or in from three to four weeks (see page 579).

Myxœdema is a very rare, well-characterized disease of decided pathological interest which has been much studied recently, especially by Gull, Ord, Virchow, Kocher, Horsley, Stephen, Mackenzie, Schiff, Eiselsberg, and others. This affection, which was first described by Gull in 1873 as the "cretinoid state," attacks women more frequently than men, and appears usually in middle life. There is always a fibroid degeneration of the thyroid gland. This interstitial proliferation of connective tissue, which results from an inflammatory process, is also very frequently found in the skin and in the internal organs. There is a striking abundance of mucin in the skin and in the blood. Disturbances in speech, in locomotion, and in intellect are also observed. After experimental removal of the thyroid gland in animals, and its complete removal in man, there likewise ensues a state called cachexia thyreopriva, which corresponds exactly to myxœdema. Only partial removal of the gland is permissible, therefore, in man. Schiff and Eiselsberg showed that animals survive total extirpation of the gland if one taken from themselves or from another animal of the same species is grafted into the peritoneal cavity or the abdominal wall, so that it continues to perform its function. The function of the thyroid gland by which the accumulation of mucin in the body is prevented is disturbed in myxœdema. The latter occurs as well after operative removal as after degeneration of the gland. It is probably identical with the so-called sporadic cretinism in children, and closely related to endemic cretinism. A degeneration of the thyroid gland—or a goître—is usually found in cretins, and the gland is sometimes absent. The final causes of degeneration of the thyroid gland are unknown. Myxœdema usually results fatally in a few years. Cachexia following total removal of the thyroid gland, which was first described by Reverdin as operative myxœdema, appears in man several months after the operation, and begins with general languor, cold and numbness in the extremities, and thickness of speech. The face is waxy white, puffed up, and has a strikingly idiotic expression. Intelligence is diminished, and likewise the will power. Hoffa observed epilepsy. In young persons growth may be retarded. The main features are disturbance of the normal cerebral functions, anæmia, with diminution in the number of the red blood-corpuscles (Kocher, Horsley), a marked accumulation of mucin in the body (myxœdema), and finally symptoms of tetany. According to Zanda, the formation of the poison in cachexia thyreopriva takes place mainly in the spleen; by extirpation of the latter before and after removal of the thyroid in dogs, the cachexia was avoided or improved. The evil effects of extirpation of the thyroid in animals have been carefully studied by Schiff, Horsley, Wagner, Eiselsberg, and others, and they all come to the same conclusion—viz., that this operation brings with it great danger and ultimately death.

By way of treatment in myxœdema and cachexia thyreopriva the administration of raw thyroid glands from sheep or calves (one or two a week or two to five grammes a day, depending on the age of the patient), and the hypodermic injection of alcoholic or glycerin extracts of thyroids of sheep

or calves, are to be recommended. In my experience the administration of fresh raw thyroids is the most effectual. They should be freed from fat and capsule with sterile instruments, chopped fine, spread on bread, and eaten with salt. If it is impossible to get fresh thyroids, one may use thyroid tablets, which are usually kept by druggists, and inject at the same time the alcoholic or glycerin extract of the thyroid gland. The patients who are treated in this way must be carefully watched, as symptoms of intoxication sometimes result (symptoms of exophthalmic goître, syncope, increased pulse rate, etc.). One must be particularly cautious in the case of persons with heart disease. As a last resort, one may graft thyroid-gland tissue into the abdominal wall, as has been done by Lannelongue, Merkeln, Walther, and others. Eiselsberg recommends the insertion of perfectly fresh human gland tissue between the fascia and peritonæum in such a way that a portion of the gland projects into the peritoneal cavity.

Tetany following complete extirpation of the thyroid gland is caused by a peculiar irritable condition in the anterior horns of the gray substance of the spinal cord. It is characterized by attacks of tonic contraction of special groups of muscles, particularly on the extremities. The attacks last some minutes or hours, or even for a day or two, and occur at variable intervals. The spasms sometimes affect the muscles of mastication and of the face, likewise those of the shoulder and the trunk, the diaphragm, etc., so that severe attacks of dyspnœa occur (also from spasm of the glottis). The spasms may be produced by compressing the vessels or nerves of the arm for a minute or two (Trousseau's phenomenon); also by compression, according to others of the dorsal vertebræ or the cervical sympathetic. The irritability of the branches of the facial nerve is also characteristic. A light stroke with the finger from the temple to the lower jaw causes a lively contraction of all the muscles supplied by the facial nerve. The electric excitability of the nerve is increased. In case even of a small goître, tetanus from anodal and cathodal opening occurs, which has otherwise never yet been observed in man (Erb, Chwoster). The cause of these convulsive attacks from goître extirpation (they occur, as is known, from various causes) was formerly sought in the irritation of peripheral sympathetic nerves—e. g., resulting from ligation of a great many vessels (Weiss) or from division of the numerous nerves of the thyroid gland. According to Schiff, Wagner, Horsley, Eiselsberg, Schwarz, and others, this tetany is not observed after partial extirpation of the gland—never, for example, after extirpation of one half, but only after its complete removal. According to Eiselsberg's experiments upon cats, the extirpation of four fifths of the gland likewise occasions tetany in every case, but it does not always cause death, while tetany following complete extirpation of the gland is always fatal. Eiselsberg, in four cases, succeeded in grafting the thyroid gland into the abdominal wall in cats, then extirpated this gland which was performing its function, and all the animals died of typical tetany. The causal connection between tetany and the suspension of the function of the thyroid gland is accordingly established. According to Horsley, Wagner, and Eiselsberg, the function of the thyroid gland probably consists in changing mucinoid substances into such as are harmless. After complete extirpation of the gland, mucin accumulates in the tissues (myxœdema), and death ensues from mucin-poisoning, with

tetanic symptoms. Entire removal of the gland is borne by herbivora—rabbits, for example—better than by carnivorous animals—e. g., dogs, foxes (Sanguirico).

The course of this form of tetany is sometimes acute or subacute, and sometimes chronic. That produced experimentally in animals seems to have a more rapid course than that observed in man. The duration depends mainly upon the size of the portion of the gland that is left. In animals, tetany following complete extirpation of the thyroid gland runs a course of several days, or, at the longest, of from three to four weeks. In man, aside from the acute form, there are mild cases, lasting as long as ten years. In such instances the other symptoms of cachexia thyreopriva are correspondingly pronounced. Tetany following complete extirpation of the gland is always fatal. The diagnosis of tetany is easy in view of the characteristic symptoms that have been mentioned.

The treatment of this form of tetany is the same as that of myxœdema (see page 578). Contrary to the experience of other authors, Schwarz had no success in cases of experimental tetany, resulting from the extirpation of the thyroid gland in dogs, from the intravenous or intraperitonal injection of thyroid extract. Warm baths with showers of cold water have also been recommended, as well as injections of morphine, an ice bag or ether spray upon the vertebral column, the galvanic current (cathode upon the sternum, anode over the spinal cord and separate nerve trunks, beginning near the muscles and slowly moving upward, Erb), etc.

The majority of authors now properly agree, in view of the facts at hand, that tetany, cachexia thyreopriva, and myxœdema are related diseases. Reliable observers like Kocher, Billroth, Eiselsberg, Mikulicz, Gussenbauer, and Stelzner have seen tetany pass into cachexia, and Horsley was successful, on the other hand, in changing the acute form of tetany in monkeys into the chronic form of myxœdema.

All these disturbances have only been observed after complete removal of the thyroid gland, and it follows from this that the total suspension of the function of this gland is attended with serious danger to the human organism. Complete extirpation is therefore physiologically not permissible. It should only be performed in a case of necessity, as a last resort, when the life of the patient is endangered. In operating upon goître, one should hold firmly to the principle that a portion of the gland is to be left which is capable of performing its function, is well nourished, and is not separated too far from its surroundings. One must therefore always confine himself to the extirpation or resection of one half of the gland or the intracapsular enucleation of the goître as first practised by Socin. In case of diffuse malignant disease of the entire thyroid gland, operation is contraindicated; and in case one side is thus affected, an effort should be made to preserve the other half as far as possible. Even when there is extreme compression of the trachea or the œsophagus, one half of the gland should be left. In suitable cases, before complete extirpation of the

gland is resorted to, grafting thyroid gland tissue into the abdominal wall should perhaps be tried.

We distinguish the following forms of thyroidectomy, proceeding upon the hypothesis that the operation involves only one half of the gland, while the other half is wholly or partially sound. The operation is performed under chloroform or ether. It is a good plan to use chloroform at the outset, and to finish the operation with ether. In suitable cases cocaine anæsthesia may be employed.

1. Extirpation of one half of the thyroid gland is indicated in cases of malignant and diffusely inflamed goître. If normal gland tissue is wanting on the other side, extirpation is contraindicated, or is only allowable as a palliative operation.

2. The intracapsular enucleation of goître nodules (Socin) from the surrounding normal gland tissue is indicated in cystic goîtres and in other nodular forms of goître. If great difficulties arise, or severe hæmorrhage occurs, resection of half the gland may be performed. This is, however, usually unnecessary. It has recently become more and more evident that intraglandular enucleation is practicable in all non-malignant goîtres, as Socin first maintained. It appears from a tabulation by Bally of seventy-seven cases of enucleation in Socin's clinic that the results as regards recurrence are quite as good as those secured by the removal of one half of the gland, that paralysis of the recurrent laryngeal nerve can always be avoided, and that already existing slight paralyses of the same nerve may disappear.

3. The evacuation (*évidement*) of goître nodules after Kocher—that is, opening the nodules and removing them and their contents with the fingers or sharp spoon, is closely allied to the method just mentioned. Kocher especially recommends this method for circumscribed nodules of soft consistence in comparatively well-preserved gland tissue, and also for soft nodules which have numerous vascular connections with the surrounding parts.

4. Resection of goître by Mikulicz's or Kocher's method (see page 587) takes the place of extirpation and enucleation in the numerous cases which do not clearly conform to the above-cited indications. This operation, especially Kocher's (see below), may be employed for all goîtres.

5. Ligation of the arteries of the thyroid gland, the superior and inferior thyroid, was recommended by Billroth, Wölfler, Rydygier, and others, to bring about a diminution in the size of the goître. The rapidly growing, parenchymatous, vascular goîtres in young persons are especially suited to this treatment. Success is scarcely to be expected in cases of fibrous and cystic goîtres. Billroth, Rydygier, and

others have secured good results from the ligation of all four arteries —that is, the two superior and the two inferior thyroids. A gradual atrophy takes place, and necrosis is not to be feared. In cases of vascular, parenchymatous goîtres, Rydygier recommends the ligation of all four arteries at a single sitting. Wölfler and Porta had favourable results from unilateral ligation of the superior and inferior thyroid arteries. According to Kocher, ligation is indicated in vascular goîtres, and especially in exophthalmic goître. Only those arteries should be tied, however, which supply that portion of the gland where the symptoms of the disease are most pronounced, and the last artery of the gland should not be ligated until one has convinced himself that atrophy has not taken place in the portion of the gland that is supplied by the arteries that have already been tied—in other words, that the ligation has not had the desired effect. The question whether cachexia follows the ligation of all the vessels can not as yet be decided with certainty. Wölfler does not share Kocher's fears in this direction. Atrophy takes place gradually, and sufficient functionating gland tissue remains. For the technique of ligation of the superior and inferior thyroid arteries, see pages 584 and 585, as well as Figs. 289 and 290, pages 564 and 565.

The technique of the various operations for goître that have just been enumerated is as follows:

Thyroidectomy.—The skin incision for thyroidectomy is made differently, according to the situation and the size of the tumour. It may be made in the median line of the neck, for instance, or along the anterior border of the sterno-mastoid muscle, or, finally, an angular or curved incision may be preferred. From a cosmetic standpoint, a transverse incision often gives the best results. In the further course of the operation, injury to the recurrent laryngeal nerve, as well as to the sympathetic and its branches, is especially to be avoided. Regarding the topography of the latter, Drobnik in particular has recently made some thorough investigations. The recurrent laryngeal nerve may also easily be injured in ligation of the inferior thyroid artery, or included in the ligature (see pages 564 and 565, Figs. 289 and 290).

After dividing the skin, superficial fascia, platysma, and the overlying muscles and exposing the goîtrous tumour with blunt instruments and the fingers, the superior and inferior thyroid arteries are found and tied, together with their veins. It is of importance that the fascial capsule (not the glandular capsule) be divided before enucleation of the goître and before ligation of the vessels. Ligatures *en masse* should be avoided as far as possible throughout the operation. The superior and inferior thyroid arteries must of course be isolated before

being tied. One easily finds the superior thyroid artery and its vein at the upper end of the goîtrous tumour if one here passes upward on the anterior surface along the vessels. Kocher recommends a special grooved director (Fig. 297) for use in tying the vessels. It is also serviceable in enucleating the goître. After double ligation of the superior thyroid artery and vein, and division of the same between the ligatures, the larger veins are tied on the upper, median and outer borders, and the goître is here freed with the fingers or a blunt instrument. This blunt detachment of the border of the thyroid gland must be done with great care, and one must always look out for any large veins that leave the gland. One gradually approaches the lower edge of the gland, and here comes upon the inferior thyroid artery and vein and, it may be, the (inconstant) arteria thyreoidea ima. Injury or inclusion of the recurrent laryngeal nerve while tying the inferior thyroid artery is most surely avoided by isolating and tying the trunk of the vessel proximally from its point of division into its two main branches. It must be remembered, however, that in the vicinity of the proximal part of the artery branches of the sympathetic nerve as well as the middle cervical ganglion may be injured. The recurrent laryngeal nerve passes upward to one side of the trachea and the œsophagus. It lies in front of or behind the transversely situated inferior thyroid artery—that is, it usually crosses the artery near the place where the latter divides into an ascending and a descending branch (see pages 564 and 565, Figs. 289 and 290). To avoid also any injury to the sympathetic nerve and the middle cervical ganglion, Drobnik has recommended ligation of the thyroid axis. Ligation of the inferior thyroid artery demands especial care. Its wall is often very thin and strikingly fragile. After tying it, its two branches should be divided close to the gland.

Fig. 297.—Kocher's grooved director for operations on goître.

The detachment of the lower border of the thyroid gland is especially difficult in cases of substernal goître. Blunt separation of the gland from the trachea is usually easy, but it should be performed with the greatest caution and without compression of the latter. In the removal of one half of the thyroid gland the isthmus is tied by a ligature *en masse*, or, better, divided and the vessels tied separately.

Bottini operates as follows: After exposure of the tumour the isthmus is found, and from here one lays free the lobe which is to be removed. At the upper and lower poles of this lobe artery clamps

are applied at the places where the vessels enter and emerge, and all the vessels are tied and divided.

Ligation of the Arteries of the Thyroid Gland.—If it is desired merely to ligate the superior and inferior thyroid arteries without removing the goître, the best incision is one along the outer border of the sterno-mastoid muscle (Billroth, Drobnik). The superior thyroid artery arises from the external carotid just above the point of division of the common carotid, on a level with the upper border of the thyroid cartilage. It first passes upward and then curves downward until it reaches the upper edge of the lateral lobe of the thyroid gland, in which it runs in the direction of the isthmus. The incision parallel to the outer border of the sterno-mastoid muscle begins near the angle of the jaw. After dividing the skin, the platysma, and the superficial fascia, one easily finds the artery at the upper border of the lateral lobe of the thyroid gland by keeping in mind the anatomical relations just given.

There are various methods of tying the inferior thyroid artery. Drobeck's method, recommended by Rydygier, is as follows: An incision through the skin is made along the outer border of the sterno-mastoid muscle from the level of the thyroid cartilage to a point one to two centimetres above the clavicle. The scalenus anticus muscle is exposed by pushing to one side the adipose tissue and the lymph glands on the outer border of the sterno-mastoid muscle or along the internal jugular vein. A lymph gland beneath the omo-hyoid muscle is removed, if necessary, which must be done cautiously, as the superficial cervical artery lies underneath. Upon the scalenus anticus muscle, which now lies exposed, the phrenic nerve is found passing from above downward and inward, and, a little higher, the ascending cervical artery. If now the sterno-mastoid muscle, the jugular vein, the common carotid, and the pneumogastric nerve are retracted toward the median line, one easily reaches the thyroid axis or the inferior thyroid artery by following the ascending cervical artery, or one feels for the carotid tubercle. The arch of the inferior thyroid artery lies in adults one centimetre, in younger persons from two to three centimetres, below the carotid tubercle, close to the inner border of the scalenus anticus muscle. The artery lies in the cleft between the scalenus anticus and longus colli muscles, and is covered by the deep cervical fascia, which should be divided before the artery is ligated.

Drobnik has called especial attention to the importance of not injuring the cervical sympathetic in ligating the inferior thyroid artery (see page 565). He therefore recommends an incision along the outer border of the sterno-mastoid muscle. After dividing the omo-hyoid muscle the superficial cervical artery appears. By following this inward

one comes to the thyroid axis, which is then tied between the origin of the superficial cervical and the ascending cervical arteries. Injury to the main trunk of the sympathetic nerve and its branches is in this way impossible, as they all lie farther inward. Should the distance between the superficial and ascending cervical arteries be too short, the thyroid axis is tied proximally from the point of origin of the ascending cervical artery.

Rydygier has recommended the following method of ligating the inferior thyroid artery: An incision six to eight centimetres long is made two centimetres above the clavicle and parallel to it, so that a little less than half the incision lies over the sterno-mastoid muscle. After dividing the skin, platysma, and superficial cervical fascia, the loose cellular tissue is detached from above downward, beneath the sterno-mastoid muscle, in order to gain access to the inner border of the scalenus anticus muscle. The large vessels and the pneumogastric nerve remain undisturbed on the posterior surface of the sterno-mastoid muscle, and are lifted upward with the finger. One or two long, blunt retractors are inserted into the cleft that is thus made, and the sterno-mastoid is drawn forward and inward, together with the large vessels and the pneumogastric. One now sees the thyroid axis pulsating in the gaping cleft to the inner side of the scalenus anticus, and the inferior thyroid artery passing inward in a curved direction. The artery is then isolated, and ligated in two places. The phrenic nerve, which runs upon the scalenus anticus muscle, from above and outward, downward and inward, can not be injured.

The older methods of Velpeau and Langenbeck for the ligation of the inferior thyroid artery are not to be recommended, because they involve too great danger of injury to the sympathetic nerve. The oldest method of ligating this artery is that of Velpeau. An incision is made along the inner border of the sterno-mastoid muscle. The latter is drawn outward with the common carotid, which lies beneath, and with the internal jugular vein and the pneumogastric nerve, while the trachea and the thyroid gland are drawn in the opposite direction. After dividing the omo-hyoid muscle and the layers of fascia, one sees the second inner curve of the inferior thyroid artery (see Fig. 290, page 565). Of the branches of the sympathetic nerve, one here sees, by looking carefully, the first cardiac branch and, it may be, its anastomotic branches to the recurrent laryngeal or the communicating branch of the superior laryngeal.

The danger of injury to branches of the sympathetic nerve is still greater in Langenbeck's method: An incision is made between the sternal and clavicular portions of the sterno-mastoid muscle. After widening the cleft between the two portions of the muscle, the common carotid artery, the internal jugular vein, and the pneumogastric nerve are drawn outward, and the artery is sought deeper down. Wölfler utilizes the same muscular cleft, but draws the large vessels and the pneumogastric nerve inward. The outer curve of the inferior thyroid artery is exposed; but here lie the middle cervical ganglion and the main trunk of the sympathetic nerve which divides into numerous branches.

Enucleation.—The intraglandular removal of goître nodules is much simpler than the above-described extracapsular extirpation of the goître or the thyroid gland; and this method, which was first perfected by Socin, may be applied to nearly all forms of non-malignant goître. The intraglandular enucleation of cystic goîtres has been practised for a long time by Julliard, Rottmann, Reverdin, Burkhardt, the author, and others. The operation is a simple one for the experienced surgeon, and it can be performed quickly. It is based upon the experience that cystic and other goîtrous nodules are shut off from the normal gland tissue by a more or less thick capsule. In performing the operation, one must keep to this natural boundary, and the enucleation is to begin only after the capsule has been distinctly made out. If one does not do this, he either works backward into the substance of the gland, causing great hæmorrhage, or the operation assumes the form of a much more laborious extracapsular extirpation of the part of the gland that is involved.

The main thing, then, is to expose the goître as described above and divide the glandular tissue which overlies the nodule until one comes upon the capsule of the latter, which is usually bluish, transparent, and non-vascular. Before dividing the capsule of the gland, one must always convince himself as to the nature of the tumour tissue lying beneath. If one makes a mistake here, and the goître proves to be one which is not adapted to enucleation, annoying hæmorrhage may result. After the goître nodule is reached it is bluntly enucleated. Only when a thick layer of glandular tissue is to be divided is it necessary to seize it with clamps and divide it gradually. The nodules often have a very superficial situation, so that they can be enucleated immediately upon opening the capsule. One can thus remove two or more nodules through one or several incisions. The advantage of the intraglandular method consists especially in the fact that injuries to the large vessels and the nerves are surely avoided. The hæmorrhage, however, may be severe. It is a good plan in suitable cases, according to Hahn, Niehaus, and Zesas, to shut off temporarily from the circulation the part of the thyroid gland that is to be operated upon by clamping the superior and inferior thyroid arteries. The part of the gland that is involved can sometimes be rendered bloodless, according to Bose, by tying it off with an India-rubber tube. This method described by Bose is as follows: After the enlarged half of the thyroid gland has been exposed, the loose connective tissue that surrounds the capsule is bluntly detached, until the greater part of the tumour can be lifted out through the wound in the skin. If exceptional difficulty attends the blunt detachment of the superior cornu of

the gland, its upper vessels are tied and divided. An elastic ligature is now laid about the base of the tumour and the nodules and cysts can then be very easily enucleated without hæmorrhage, making as many incisions in the gland substance as one wishes. After removing the constriction, the gland tissue that is left is compressed for a short time, and the vessels, which are small ones, are tied if necessary.

The technique of Kocher's method—that is, the removal of goître nodules with the fingers or the sharp spoon—is essentially the same as that of intra-glandular enucleation after Socin. The only difference is, that in the former method the capsule of the gland is not first divided and the nodules then enucleated, but the nodules are divided immediately, and the two halves taken out with the fingers and the sharp spoon.

Mikulicz's method of resection of a struma is performed as follows:

The goître is, in the first place, exposed in the usual way, just as in extirpation, and one half is isolated, so far as it can be done bluntly. The superior thyroid artery and vein are then tied at the superior cornu in the regular way, and the superficial vessels going to the inferior cornu are likewise tied. The isthmus is then bluntly detached from the trachea and divided between two ligatures. The pedicle of the entire mass of the goître, which is still attached in the angle between the trachea and œsophagus, covering the recurrent laryngeal nerve and the inferior thyroid artery, is then divided longitudinally with blunt scissors, large clamps being used to seize the tissue as it is divided, and ligature stumps left from five to ten millimetres in length.

Kocher has modified this method of Mikulicz in the following way: The superior and inferior thyroid arteries are ligated as a preliminary operation, just as in extirpation. If one wishes to be perfectly sure of preserving gland tissue which is capable of performing its function, this part of the operation is omitted, and the isthmus is ligated immediately after the anterior surface of the goître has been exposed. At the hilus or base of the goître a vertical incision is made into the gland tissue down to the nearest nodule. The capsule of the gland is now detached, bluntly or with scissors and knife, from the median surface of the nodule, with ligature of bleeding vessels, until the posterior surface of the nodule is reached, where one is surely outside of the recurrent laryngeal nerve. The capsule of the gland is then finally divided at this point. By this method, therefore, the goîtrous tumour is really extirpated at its base after circular division of the capsule of the gland.

After every thyroidectomy the wound should be thoroughly irrigated with a 1-to-1,000 bichloride solution, drained at its lowest part, and closed by suture. I often use glass drains, which are removed in twenty-four to forty-eight hours. If the operation is aseptic, even very large wound cavities heal by primary union in from eight to ten days. The antiseptic protective dressing covers neck, thorax, and head, as represented in Fig. 3, page 10. In suitable cases packing the wound with iodoform gauze should be substituted for drainage and suture. After the packing has been removed, the wound may, if neces-

sary, be closed by secondary suture. The head of the patient should be kept as low as possible, especially after extirpation of a substernal goître, to aid in the discharge of the secretions of the wound.

Poncet, Sydney, Jones, Wölfler, and others have brought about shrinkage of goîtres by drawing them out through the external wound and retaining them here with sutures (Exothyropexy, *seu* Thyroidectesis, *seu* Thyroideorrhaphy). This method is thought to be particularly applicable to retrovisceral and intrathoracic goîtres and to Basedow's disease.

The behaviour of the portion of goître that is left behind after thyroidectomy is variable. It sometimes shrivels considerably; in other cases it remains stationary or continues to grow. According to Salzer, who reported two hundred and eighty cases of thyroidectomy performed by Kappeler, it is rare for what remains of the goître to diminish in size spontaneously.

Of six hundred and twenty-five goître extirpations, eighty-six, according to a compilation made by Jankovski, were attended with laryngeal disturbances, in consequence of division, laceration, or contusion of the recurrent laryngeal nerve, consisting in unilateral or bilateral paralysis of the vocal cords. In unilateral paralysis there is hoarseness, and in bilateral paralysis extreme dyspnœa also, so that immediate death may ensue (see § 105, page 613). Paralysis of the vocal cords is not infrequently observed before the operation, resulting from pressure of the tumour upon the recurrent laryngeal nerve. It has already been shown (pages 584, 585) how the recurrent laryngeal nerve can be most surely avoided, especially during ligation of the inferior thyroid artery.

E. Rose said that tracheotomy should always be performed in thyroidectomy, to avoid accidents from asphyxia. This view is not held at present, tracheotomy being performed only when suffocation is threatened. High or low tracheotomy is selected, according to the size and the situation of the goître—that is, the special case decides where the trachea is to be opened (see pages 618–621 ff., Tracheotomy). If the trachea is flattened from in front backward, its anterior wall must be lifted forward with tenacula before it is opened. After tracheotomy has been performed, a wide canula of as great length as possible is introduced—e. g., the one devised by König, which has been modified by Genzmer (see Fig. 298). Salzer's canula, as well as Kocher's, is also good. Salzer's consists of a long, straight portion, that lies in the wound, with a short bend and a movable neck piece. Kocher's canula, whose lower displaceable end is rigid for a few centimetres, is described in the Monatschrift der ärztlichen Poly-

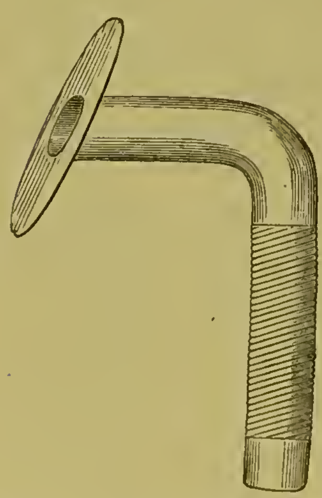


Fig. 298.—Canula for substrumal tracheotomy.

technik, 1888, p. 133. Long œsophageal tubes should also always be at hand. Tracheotomy should never be put off till the moment of extreme danger, nor is it a good plan for the operation for removal of the goître to follow it immediately.

Retrovisceral goîtres (see page 573) are, generally speaking, only to be extirpated when they occasion decided discomfort, especially dysphagia and dyspnœa, from pressure upon the pharynx, the œsophagus, and the trachea. Their removal may be attended with great difficulties.

If, in case of a retrovisceral goître with dyspnœa, normal thyroid tissue is absent, one may displace the goître upward and suture it to the inner surface of the sterno-mastoid muscle (thyroideorrhaphy). Intrathoracic goîtres are treated on the same principles—i. e., extirpation or displacement.

In all inoperable cases of goître the internal administration of fresh raw thyroid gland or thyroid-gland tablets is indicated (see page 576).

The treatment of acute strumitis consists at first in the application of ice, preferably by means of the ice coil. In case of abscess, prompt incision is necessary. If there is stenosis of the trachea, tracheotomy may become imperative. The treatment of malignant goîtres consists in their earliest possible extirpation in the manner which has been described. Patients often come under surgical treatment too late for a radical operation, and one must then confine himself to lessening the difficulty in breathing by tracheotomy and keeping up the strength by good nourishment, given, if necessary, through the stomach tube.

§ 100. **Injuries and Diseases of the Thymus Gland.**—The thymus is a glandular organ which during the fœtal period and the first two years of life attains some size and then ceases its growth. Atrophy begins from about the tenth year, and the loss is replaced by adipose and connective tissue. The thymus lies in the anterior upper mediastinal space, behind the upper part of the sternum, in front of the large vessels, and above the base of the heart. It consists of two longitudinal lobes and reaches nearly to the thyroid gland. As in the case of the latter, so here also accessory (isolated) glandular lobules occur.

Of pathological changes in the thymus there should be mentioned delay in retrogression until from the twentieth to the fortieth year, hæmorrhages, suppurative inflammations, tuberculosis, syphilitic gummata, and tumours (sarcoma, etc.). Operations on the thymus gland are unknown to me. It would be necessary to perform them with the greatest caution, at all events, in view of the position of the organ as just described. For a description of status thymicus (Paltauf) see page 566. Mikulicz employed with success thymus feeding (10 to 25 grammes two or three times a week) in goître and Basedow's disease.

CHAPTER XI.

INJURIES AND DISEASES OF THE LARYNX AND TRACHEA.

For *injuries*, see § 88, page 504, and § 92, p. 530.—*Examination of the larynx* (*laryngoscopy*).—Congenital malformations.—*Inflammations :* Catarrh.—Pseudo-croup.—Croup.—Diphtheria.—Laryngitis submucosa acuta (phlegmon) and chronica.—Œdema of the larynx (œdema of the glottis).—Erysipelas.—Tuberculosis.—Syphilis.—Leprosy.—Perichondritis and chondritis of the Larynx.—*Tumours*.—*Foreign bodies*.—*Neuroses* (spasm, disturbances in co-ordination, paralyses). *Operations on the larynx :* Thyrotomy.—Infrathyroid laryngotomy, with or without cricotomy.—Tracheotomy.—Intubation.—Tamponing the larynx and the trachea.—Excision and resection of the larynx.

§ 101. **Examination of the Larynx.**—The examination of the larynx consists in inspection and palpation from without, and especially in inspection from within by means of the laryngoscope (laryngoscopy). Garcia and Türck were the inventors of the laryngoscope, while the credit of perfecting laryngoscopy as a method of diagnosis and introducing it into surgical practice belongs to Czermak (1858). Since the invention of laryngoscopy, the treatment of diseases of the larynx has made marked progress, and it has become a special branch of medical science. Every physician, however, and every surgeon should be thoroughly familiar with laryngoscopy, and must be able to recognise the most important pathological conditions.

Introductory Anatomical Remarks.—The larynx, which is attached above to the hyoid bone and becomes continuous with the trachea, lies, when at rest, between the upper border of the third and the lower border of the sixth cervical vertebra. The framework of the larynx consists of nine cartilages, the thyroid, the cricoid, the epiglottis, and three cartilages in pairs—viz., the arytenoid, the cartilages of Wrisberg (cuneiform cartilages), and the cartilages of Santorini. The thyroid cartilage is connected with the hyoid bone by means of the thyro-hyoid membrane, and with the cricoid cartilage by means of the crico-thyroid membrane. The remaining space on the side between the thyroid cartilage and the cricoid cartilage is filled by an elastic membrane. The cricoid cartilage has the form of a seal ring, whose broader surface lies behind. On the highest point of its upper posterior border is found on each side a smooth oval surface for articulation with the arytenoid cartilage, and on each external surface upon a slight projection is the articular surface for the thyroid cartilage.

The epiglottis, which stands almost vertical in adults, is attached to the base of the tongue by the median and two lateral epiglottidean ligaments, and to the notch at the upper border of the thyroid cartilage by the thyro-epiglottic ligament. The epiglottis is attached to the arytenoid cartilage on each side by the aryteno-epiglottidean folds.

Fig. 299.—The laryngoscopic picture during normal respiration (Heitzmann).

The most movable cartilages of the framework of the larynx are the arytenoid. They form inwardly inclined pyramids, and make possible the movements of the posterior portion of the larynx, which are of the greatest importance for respiration and phonation. They articulate with the cricoid cartilage. At the base of the arytenoid cartilages are two processes: the muscular process for the insertions of the lateral and posterior crico-arytenoid muscles, and the vocal process, which forms the boundary between the cartilaginous and the ligamentous portions of the vocal cord. On laryngoscopic examination this process is to be seen as a transparent, yellowish point (see Fig. 299).

The small, spherical cartilages of Santorini are situated upon the tip of the arytenoid, and the cuneiform cartilages in the aryteno-epiglottidean folds. The cartilages of Santorini and the cuneiform cartilages share the movements of the posterior point of insertion of the vocal cords.

The most important ligament for the function of the larynx is the vocal cord (ligamentum vocale). The vocal cords are attached in front to the angle between the alæ of the thyroid cartilage immediately beside one another, then diverge, and are inserted on each side to the vocal process of the arytenoid cartilage. Hence their designation as inferior thyro-arytenoid ligaments. The superior thyro-arytenoid ligament lying on each side, in a fold of mucous membrane, forms the false vocal cord. The pyriform sinus lies on each side, external to the aryteno-epiglottidean folds. The ventricle of the larynx is an oblong fossa, situated between the true and the false vocal cords. The tissue of the true cords consists, aside from the fibrous and elastic elements, of the muscular fibres of the inferior thyro-arytenoid which makes the vocal cord tense. The vocal cords when at rest form with each other a narrow isosceles triangle (Fig. 299). During deep inspiration they become farther separated. During speech, on the contrary, the space between them, the so-called rima glottidis, is more or less diminished—that is, the vocal cords approach each other, according to the tone produced, either in their entire length or leave, in falsetto, for example, an elliptical cleft between.

The false vocal cords also have a similar motion, but their edges never touch each other under normal conditions during speech, although they do so during the act of swallowing. Under pathological conditions they may act as tone-producing organs in place of the true vocal cords when the latter are diseased or absent.

The following are the muscles of the vocal cords: 1. The dilator of the rima glottidis (abductor), the crico-arytenoideus posticus, paralysis of which is dangerous to life and by whose bilateral paralysis immediate asphyxia may ensue. 2. The constrictors of the rima glottidis (adductors)—viz., the crico-arytenoideus lateralis, the arytenoideus transversus between the two lateral borders of the arytenoid cartilages, the crico-thyroid, and the thyro-arytenoid muscles. The latter is found in the substance of the vocal cords. By this the cords are made more or less tense and at the same time approximated. They are also stretched by the crico-thyroid muscle—that is, they are drawn in a longitudinal direction, and the glottis is likewise contracted.

The muscles also which serve for the fixation, raising, and lowering of the larynx may work in part upon the vocal cords. The latter are, for example, relaxed by some of the fibres of the sterno-thyroid muscle.

The nerves of the larynx are the superior laryngeal and the recurrent laryngeal.

The superior laryngeal nerve is in the main a sensory nerve. In contains only one motor branch for the crico-thyroid muscle.

The recurrent laryngeal nerve receives its fibres from the anterior or inner branch of the spinal accessory, which pass into the pneumogastric below the jugular ganglion and run downward in the cervical portion of the latter till they again leave the pneumogastric on a level with the apices of the pleura on the right side in front of the subclavian artery and on the left at the lower border of the arch of the aorta. The recurrent laryngeal nerve from here passes upward behind the carotid, and then between the trachea and the œsophagus, and pierces the inferior constrictor of the pharynx at the lower corner of the plate of the cricoid cartilage. The recurrent laryngeal nerve supplies all the muscles of the larynx, with the exception of the crico-thyroid, which is supplied by the superior laryngeal nerve.

The centre for the voluntary movements of the larynx lies, in the dog, according to Krause, in the cerebral cortex in the gyrus præfrontalis between the sulcus cruciatus and the frontal lobe.

The arteries of the larynx are the superior laryngeal and the crico-thyroid, both of which arise from the superior thyroid artery, and the inferior laryngeal, from the inferior thyroid artery. The veins open into the internal jugular.

The Technique of Laryngoscopy is as follows:

For the illumination of the superior aperture of the larynx and the laryngeal cavity a laryngeal mirror is used, which is introduced as far as the uvula (Fig. 300), and a reflector (Figs. 301, 302). Sunlight may be utilized or an artificial light—e. g., a petroleum or gas lamp, Drummond's calcium light, the magnesium or the electric light. The reflector serves to throw the rays of light upon the laryngeal mirror, which has been introduced

as far as the uvula. If sunlight is employed, a plane reflector is used, and with artificial light a concave one. The best way is to attach the reflector to the head of the surgeon by means of a frontal band (Fig. 302) or a spectacle frame (Fig. 301).

The patient sits opposite the person making the examination, with his back to the light in case sunlight is employed. If an artificial light is used, laryngoscopy is performed in a dark room and the lamp is situated near the right shoulder of the patient. The latter inclines his head somewhat backward, opens his mouth, sticks out the tongue as far as possible and holds it firmly with the thumb and forefinger by means of a handkerchief.

The reflector is attached to the head of the examiner and focused so that he can conveniently see with one (better the left) eye through the central opening into the pharynx, and this appears brightly illuminated. The laryngeal mirror is then warmed over the lamp, in order that it may not be covered with vapour from the breath. To avoid introducing it when too hot, the temperature is tested beforehand upon the back of the hand. The mirror is then grasped by the handle (best with the left hand) like a penholder and, while the patient intones the letter *a*, introduced into the middle line of the mouth as far as the uvula without touching the latter or the tongue. At the uvula the mirror is given a more vertical position by raising the handle and carrying it toward the right corner of the mouth. By changing the position of the mirror in different ways one obtains the laryngoscopic picture, a full understanding of which is only acquired after some practice.

Fig. 300.—Laryngeal mirror.

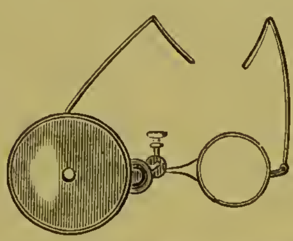


Fig. 301.—Reflector fastened to a spectacle frame.

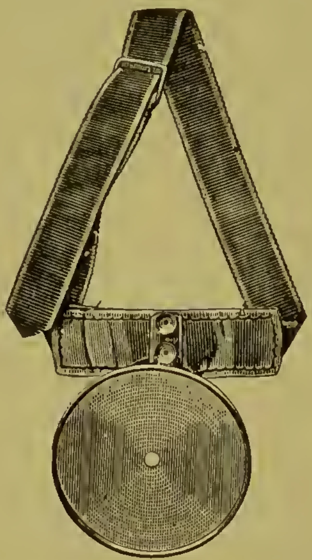


Fig. 302.—Reflector with frontal band.

One must frequently examine a normal larynx in order to be able to recognise and interpret pathological conditions.

Various circumstances may interfere with a full view of the larynx—e. g., hypertrophic tonsils, pressure of the tongue against the palate, gagging movements, etc. The extreme sensitiveness of the pharyngeal mucous membrane, which frequently disturbs laryngoscopy, is best overcome by swabbing it with a three- to five-per-cent solution of cocaine.

The laryngoscopic picture is as follows (see Fig. 299) : The parts of the larynx which lie in front—e. g., the epiglottis and the anterior commissure—are seen above in the laryngeal mirror; while the posterior portions—e. g., the

arytenoid cartilage and the posterior commissure—lie below. In looking at the single parts, one must always determine whether the colour is normal, whether swelling, inflammation, tumours, ulcers, or foreign bodies are present, whether the movement of the vocal cords is normal, etc.

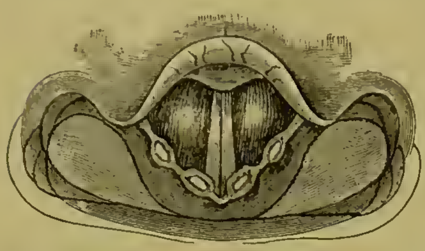


Fig. 303.—Position of the vocal cords during intonation.

One notices especially in the larynx the true vocal cords, of a glittering white colour, while all the other structures have a dull reddish appearance. Where cartilage shines through, the parts have more of a yellowish-red hue. During expiration the rima glottidis contracts, and during inspiration the vocal cords separate again. The movement of the vocal cords must be observed while the patient speaks, to determine whether or not it is normal. During phonation the cords come close together, either throughout their entire length (Fig. 303) or only at the ligamentous portion. At the boundary between the ligamentous and the cartilaginous portions of the vocal cord one sees a yellow spot, which is the tip of the processus vocalis (see Fig. 299). During deep inspiration the cords occasionally separate so widely that one can see as far down as the bifurcation of the trachea.

Between the true and false vocal cords lie the ventricles of the larynx. The false cords likewise move, but their edges touch only during swallowing or gagging, and under pathological conditions.

Above is the arched epiglottis, the base of the tongue, and the fossæ. The middle glosso-epiglottidean ligament and the lateral glosso-epiglottidean folds extend from the tongue to the epiglottis, and between them lie the valleculæ. One also sees the cartilages of Santorini, the pyramids of the arytenoid cartilage, and often the cuneiform cartilages in the aryteno-epiglottidean folds in front of the little protuberances of the cartilages of Santorini (see Fig. 299). The upper border of the posterior wall of the larynx, the interarytenoid space between the arytenoid cartilages and those of Santorini, is best visible when the glottis is widely open.

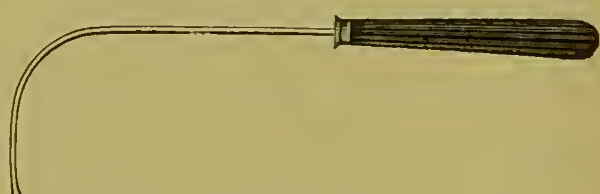


Fig. 304.—Laryngeal probe with a handle.

Other methods of examination are inspection and palpation from the outside and internal palpation of the superior opening of the larynx—e. g., in case of foreign bodies or stenosis of the larynx—and finally the use of probes curved like a catheter or bent at a right angle (Fig. 304), to determine, for instance, the consistence of tumours or the degree of sensibility of the laryngeal mucous membrane. Finally, disturbances in phonation and interference with respiration are to be regarded as important from a diagnostic standpoint.

For examining the posterior laryngeal wall and the trachea, Killian recommends using a rather large laryngeal mirror and crowding it against the soft palate while the patient stands upright with head bent forward and much

lowered, the tongue being drawn far out. The examiner himself must sit or kneel so as to look upward from below in a nearly vertical direction.

Pieniazek recommends that in suitable cases, after tracheotomy, the trachea be examined through the tracheal wound by means of a special mirror copied from Zaufal's nasal mirror. Cocaine should be applied to the mucous membrane.

Brief mention should here be made of congenital malformations of the larynx and the trachea. We have already spoken of congenital fistulæ (page 497, Malformations of the Neck). Congenital deviations of the epiglottis, the larynx, and the trachea are also of practical importance, inasmuch as they may occasion stenosis of the respiratory passages (M. Schmidt), as are also congenital tumours and membranous growths within the larynx, the so-called congenital diaphragm of the larynx. The congenital tumours are chiefly papillomata, of which P. Bruns collected twenty-three cases from the literature of the subject. The congenital diaphragm is, according to P. Bruns, a dense membranous structure stretched across between the vocal cords, by which the glottis is partially shut off. It is situated near the anterior commissure of the vocal cords, extends a variable distance backward, and here ends with a free crescent-shaped margin.

The treatment in extreme cases of congenital diaphragm of the larynx consists in intralaryngeal division of the membrane with a knife or the galvano cautery, or, in cases of special difficulty, in thyrotomy and excision. P. Bruns recommends bloodless dilatation by means of elastic, hollow bougies, just as in strictures of the larynx.

Acquired deformities of the larynx and the trachea will be described in connection with the separate diseases and operations.

§ 102. **Inflammations of the Larynx.**—The inflammatory processes of the larynx are the following: 1, Acute and chronic catarrhal laryngitis; 2, croup and diphtheria; 3, acute and chronic submucous laryngitis (erysipelatous and phlegmonous inflammations); 4, œdema of the glottis and larynx; 5, tuberculosis; 6, syphilis; 7, inflammation of the perichondrium and the laryngeal cartilages.

Acute and chronic catarrhal laryngitis have but little surgical interest. They are characterized anatomically by hyperæmia, swelling, and increased as well as altered secretion of the mucous membrane. Coughing, a hoarse, toneless voice and a feeling of pain, tickling or soreness, are the most important symptoms. Difficulties in swallowing and respiration occur particularly in acute laryngeal catarrh in children, in the so-called pseudo-croup which usually attacks children under seven or eight years of age and is characterized by a "barking" cough and paroxysms of laryngeal stenosis which are usually of short duration. The dyspnœa is partly conditioned, no doubt, upon reflex spasm of the constrictor muscle of the glottis (Gottstein).

Chronic catarrhal laryngitis comes partly from neglect of an acute laryngitis, or begins gradually as such, especially from the extension of a chronic pharyngitis. One very frequently observes chronic laryngitis in syphilis, in tuberculosis, and among habitual drinkers. It is also of frequent occurrence among individuals who are obliged to unduly strain the larynx—for

example, preachers, singers, and officers, or among those who, like millers, stonecutters, etc., breathe in a great deal of dust. Tuberculosis and carcinoma of the larynx very frequently begin with symptoms of chronic catarrh. So-called catarrhal erosions and superficial ulcers are not infrequent.

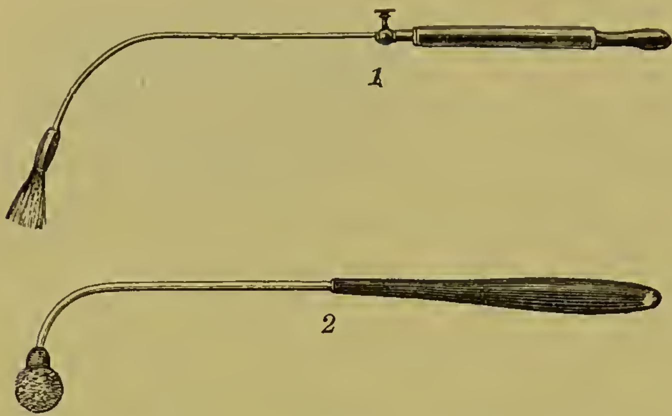


Fig. 305.—*1*, laryngeal brush; *2*, laryngeal sponge.

The secretion in catarrhal inflammation is sometimes increased and sometimes diminished (dry catarrh).

We can speak here only very briefly of the treatment of the disease. Prophylaxis is of the greatest importance—that is, careful hardening against changes of temperature and residence by the sea or in elevated health resorts that are well wooded.

In acute catarrh the voice should not be used too much. Wet external applications may be made, warm tea or milk and seltzer given internally, and inhalations employed, four-per-cent chlorate of potash, ten parts tannin with one hundred of glycerin, two- to three-per-cent boric acid, common salt, etc. In case of a painful cough, morphine is given internally. The application to the larynx of mild astringents dissolved in glycerin (copper sulphate, tannin, etc.) is especially to be recommended. The application is made under the guidance of the mirror by means of a brush or a small sponge

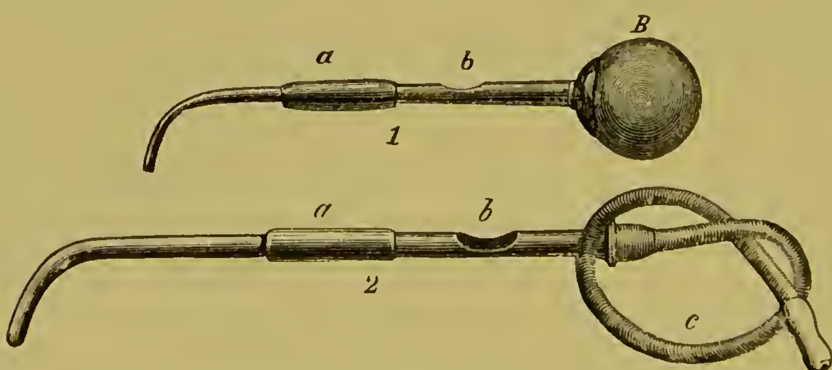


Fig. 306.—Insufflators: *a*, sliding cylinder for closing the hole *b*; *B* (*1*), bulb; *c* (*2*), rubber tube for blowing in powder (Fränkel).

(see Fig. 305). The insufflation of powders (e. g., alum, with equal parts of saccharum lactis), with the addition of morphine, is also serviceable. Insufflators are used for this purpose (Fig. 306).

In pseudo-croup, rest in bed, ice poultices or wet applications, hot drinks, inhalation, or the use of a spray to keep the air of the room moist, are particu-

larly to be recommended. Antimony and ipecac in small doses are given internally. Emetics, which used to be given, have been properly abandoned.

Chronic laryngitis is treated principally with astringents, partly by inhalation and partly by application with a brush or insufflation. In case of hypersecretion, in addition to the application of a from two- to four- or even ten-per-cent solution of nitrate of silver, inhalations of vapours of turpentine, or three parts of chloride of zinc to thirty parts of water or glycerin, are especially serviceable. In dry laryngitis the application of a solution of chlorate of potash, and then a four-, five-, or six-per-cent solution of nitrate of silver is to be recommended. In case of muscular paresis, electricity is applied by means of the galvanic and faradic current. Attention is always to be paid to the condition of the pharynx. Salt-water springs, brine baths, and sulphur springs are also advantageous, as well as hydropathic treatment at Ems, Reichenhall, etc. Residence at the seashore and in elevated health resorts is also strongly to be advised.

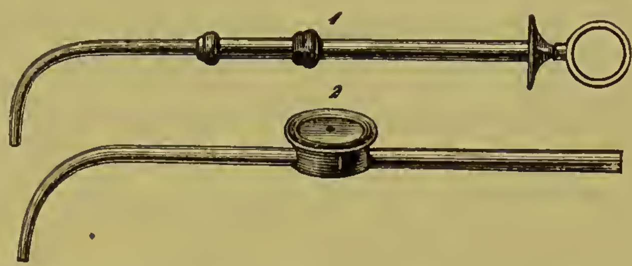


Fig. 307.—Laryngeal syringes: syringe 2 is emptied by pressing upon the elastic membrane (Fränkel).

Laryngeal Croup and Diphtheria.—Croup and diphtheria have special importance for the surgeon, because they so frequently give occasion for the performance of tracheotomy on account of stenosis of the larynx.

With reference to the pathological changes that attend croup and diphtheria, the reader is referred to the analogous diseases of the throat (see pages 411–417 ff.). We have there already emphasized the statement that there exists, in our opinion, only a difference of degree between croup and diphtheria. It need only be added here that, according to the recent investigations of Heubner, the diphtheritic pseudo-membrane is the result of a process of exudation into the epithelial layer of the mucous membrane—an exudative exanthema, as it were, of the mucous membrane. From an anatomical standpoint there exists, then, according to Heubner, scarcely any distinction between croup and diphtheria; whereas it was formerly assumed that the croupous pseudo-membrane was the more superficial, while the diphtheritic pseudo-membrane was located more deeply in the tissue of the mucous membrane. It is more correct, no doubt, in accordance with the view of Rauchfuss, Lennander (Stockholm), and others, to regard croup merely as a group of symptoms whose cause may lie in a catarrhal, fibrinous, or diphtheritic laryngitis.

The clinical course of true or membranous croup is very character-

istic. One can usually distinguish three stages. In the first, catarrhal symptoms make their appearance (cough, cold in the head, dysphagia). The general health is usually but little disturbed. Sometimes, however, it begins more suddenly without a preliminary catarrh. Two forms are usually distinguished: descending croup, which passes from the pharynx into the larynx, and the reverse of this, ascending croup. The existence of croup proper manifests itself, then, in the second stage by the coughing up of membranous shreds, by aphonia, and, above all, by more or less marked stenosis of the larynx with correspondingly laborious and sibilant respiration. The dyspnœa is occasionally interrupted by attacks of suffocation. Stenosis of the larynx presents a very characteristic and painful picture. As a result of the laborious respiration, the region above the sternum, the ensiform process, and the lowest ribs are drawn inward. In the severest cases the children lie with an anxious expression of face, are very uneasy, and not infrequently spring out of bed in their fear. Sudden death in an attack of suffocation is not very common. A fatal termination results more gradually in consequence of increasing intoxication with carbonic acid. In the latter case children gradually grow more quiet, become comatose, and respiration and pulse grow weaker and weaker until death supervenes. In case of recovery the dyspnœa is gradually relieved, and the croupous membranes are coughed out with abundant formation of mucus and pus.

According to Heubner, the diphtheritic membrane is not cast off by a process of suppuration, but gradually lifted off by the growth of the new epithelium beneath. The detachment of membranes *in toto* is probably, according to Heubner, the result of elastic processes which go on within the coagulated material.

Recovery is sometimes secured by promptly performing tracheotomy, and thus overcoming the increasing stenosis of the larynx.

The average duration of membranous croup is from six to eight days, and the result is always doubtful. The younger the child the more unfavourable is, as a general rule, the prognosis. The mortality varies very much in the individual epidemics. It is placed by many authors at ninety per cent, by others much lower, varying with the malignant or non-malignant character of the epidemic. The proportion of recoveries among children that are operated upon does not, on an average, exceed from forty to sixty per cent. In some epidemics nearly all the children upon whom tracheotomy is performed die, while in others the cases of recovery are numerous.

The same is true essentially of the course and prognosis of diphtheria of the larynx, so that it is sufficient to refer the reader to what

has just been said (see also § 67, page 417 ff., Diphtheria of the Throat). Dipththeria of the larynx resulting from that of the throat is very frequent. I have seldom observed laryngeal diphtheria without diphtheria of the throat. In other parts of the country it seems to be more common.

Secondary diseases are not so frequent after croup as after diphtheria, especially paralysis of the muscles of the throat and of accommodation. Many a diphtheritic child dies suddenly during convalescence, in from the fourth to the sixth week, from paralysis of the heart due to myocarditis.

The treatment of croup and diphtheria of the larynx is the same as that of analogous diseases of the fauces (see page 420). In the beginning ice poultices are applied, and older children are given broken ice to swallow. Gargles of chlorate of potash, boric acid, etc., are used, as well as inhalations of lactic acid, limewater, carbolic acid, etc., with which the air of the room is also to be kept moist. As soon as dyspnœa begins, tracheotomy is to be promptly performed. The sooner one operates, the greater is the probability of a successful result. The longer one waits, the more likely are fibrinous bronchitis, bronchopneumonia, and œdema of the lungs to result. After early tracheotomy the organism is more capable of contending against the diphtheria toxine. According to Lennander, fifty per cent of those operated upon early for diphtheria recovered, whereas but nineteen and a quarter per cent of those operated upon later in the disease were saved. In adults the results of operations are unfavourable, because the air passages are so wide that no dyspnœa is occasioned even by thick membranes, but begins only when the croupous process has reached the smaller bronchi. O'Dwyer was the first to recommend intubation in treating stenosis of the larynx in place of tracheotomy—that is, the introduction of metallic tubes into the larynx (see page 624). The mortality attending tracheotomy and intubation is about the same. The latter deserves the preference, perhaps, in treating children in from their first to their third year, when the exudation is confined to the larynx and the upper part of the trachea, and in desperate cases for the purpose of making death easier.

By acute submucous laryngitis is understood an acute inflammation of the larynx, which has its location chiefly in the submucous connective tissue, and occurs after injuries resulting from mechanical, thermic, or chemical causes, in severe catarrhal inflammations of the larynx, diphtheria, erysipelas, acute infectious diseases, syphilis, tuberculosis, etc.

Submucous laryngitis leads to circumscribed or more diffuse swelling of the larynx, varying in amount, which sometimes goes on to the formation of

an abscess. The affection may run its course in the form of erysipelatous or phlegmonous inflammation. In case of increasing swelling, severe symptoms of laryngeal stenosis may develop very quickly, especially when the lower part of the larynx is attacked (oedème sousglottique [Cruveilhier], laryngitis hypoglottica acuta [Ziemssen]). In severe cases death may take place suddenly from asphyxia if tracheotomy is not promptly performed.

In the chronic form of submucous laryngitis there are thickenings of the submucous tissue, especially on the epiglottis, the vocal cords, and farther down in the larynx. The course of the affection is very chronic, and the callosity and induration of the submucous tissue usually remain. This condition is dangerous, owing to the fact that serious attacks of suffocation not infrequently occur.

The treatment of acute submucous laryngitis consists in energetic use of antiphlogistic applications (ice poultices, cracked ice internally), and, in case of dyspnœa, in promptly performing tracheotomy. If an abscess develops it should be opened at once.

In treating chronic submucous laryngitis regard must be had, above all, to the cause of the disease. In case of syphilis, for example, an antisyphilitic course of treatment is indicated. The indurated areas are to be removed as far as possible by scarifications or cauterization. Strictures are treated according to general principles, especially by the introduction of intubation tubes, or laryngeal bougies—e. g., catheters of hard India rubber or blocktin bougies. These are introduced from within the mouth, under guidance of the laryngeal mirror, or through the wound in the trachea, in case tracheotomy has been performed.

By œdema of the larynx or glottis is understood an acute, serous infiltration of the mucous membrane and of the submucous tissue in particular, which is always the sequel of various local processes in the larynx and its vicinity. According to Strübing and others, œdema of the larynx may also be the result of a vasomotor neurosis, and may develop rapidly. Finally, mention should be made of larynx œdema in connection with general dropsy, resulting from disease of the heart, the lungs, the kidneys, etc.

Acute diffuse œdema which spreads over the entire larynx is observed particularly in case of erysipelatous inflammations, which arise partly within the larynx, after injuries, or spread to the larynx from the outer skin or from the pharynx. In other cases, after injuries, for instance, acute, diffuse œdema of the larynx takes the form of a phlegmonous inflammation, particularly of the submucous tissue.

The œdematous swelling in connection with œdema of the larynx is either more or less confined to a particular area or more diffuse. It is found especially where the submucous tissue is most abundant—viz., in the upper part of the larynx, in the aryteno-epiglottidean folds, on the epiglottis and its neighbourhood, near the false vocal cords, etc. The vocal cords seldom swell to a great extent, and yet in these also sufficient swelling has been observed to bring about complete closure of the rima glottidis.

The symptoms of œdema of the larynx consist principally in difficulties of respiration, as in croup and diphtheria. The dyspnœa is at first noticeable only on inspiration, because in inspiration the swollen aryteno-epiglottidean folds and the false vocal cords are pressed against each other. If the œdema

increases, expiratory dyspnœa also follows. If tracheotomy is not promptly performed, death sometimes ensues very quickly from asphyxia.

The diagnosis is made from the increasing dyspnœa and the laryngoscopic examination. By the latter the cause of the œdema is also determined. If difficulties attend laryngoscopic examination, one should at least palpate the entrance to the larynx by quickly introducing the forefinger.

In addition to acute œdema of the larynx, there is also a chronic form, which occurs mainly as the result of deep structural changes in the larynx —e. g., from ulcers or malignant new growths. Symptoms of stenosis are, as a rule, not marked, and yet acute exacerbations not infrequently occur with sudden attacks of suffocation.

The treatment of œdema of the larynx is to be directed chiefly against its existing cause, which should be determined as exactly as possible by laryngoscopic examination. For the œdema itself leeches are applied on both sides of the larynx, and use is also made of ice poultices and cracked ice internally. Multiple scarifications are also made with a laryngeal knife or a long, somewhat curved, pointed bistoury, which is wrapped with adhesive plaster nearly to the point. If dyspnœa increases, tracheotomy is indicated, and it should not be postponed too long.

Tuberculosis of the Larynx.—Tuberculosis of the larynx has recently been described very much at length in a monograph written by Heinze. It may be primary, but is more frequently secondary, following tuberculosis of the lungs. Of 1,226 cases of tuberculosis of the lungs, 276, according to Heinze, were accompanied by pronounced tuberculosis of the larynx. In case of primary disease of the lungs, the secondary infection of the larynx is usually caused, no doubt, by the sputum which contains bacilli. The reverse may also occur, tuberculosis of the larynx beginning first and leading to secondary tuberculosis of the lungs.

The pathological changes attending tuberculosis of the larynx are essentially the same as in all tubercular affections of the mucous membrane (see Principles of Surgery, § 83). From breaking down of the miliary tubercles or the more diffuse tubercular infiltration corresponding ulcers of very variable extent are formed. The tubercular disease is most frequently found upon the posterior laryngeal wall, in the interarytenoid space, on the true and false vocal cords, on the arytenoid cartilages, on the epiglottis, etc.

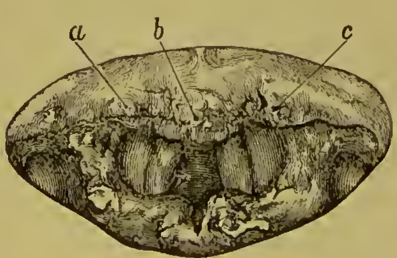


Fig. 308.—Extensive tuberculosis of the larynx: *a b c*, remains of the epiglottis (Türck).

Upon laryngoscopic examination, one usually finds at the outset a circumscribed or more diffuse induration of the part of the larynx that is involved, or more or less characteristic ulcers with a cheesy base. The destruction caused by these ulcers is frequently extensive (see Fig.

308). Miliary tubercles can not usually be recognised by laryngoscopic examination. From a diagnostic standpoint, examination of the sputum or the secretion taken directly from the surface of the ulcers is of the most value, as one can determine whether or not tubercle bacilli are present. It is of the greatest importance to note the condition of the lungs and the general health of the patient.

The symptoms of tuberculosis of the larynx are usually, at the beginning, those of an obstinate catarrhal inflammation. As the tubercular disease progresses, the symptoms consist, according to the situation and the degree of the affection, in hoarseness, going on even to complete aphonia, in a feeling of soreness in the larynx, in more or less cough and profuse secretion, attended frequently by difficult expectoration, and in dysphagia, especially in case of ulcers and tubercular infiltration of the arytenoid cartilages and the epiglottis. The duration of the disease is very variable. It depends in part upon its location, and especially upon the ability to continue to swallow normally, and still more upon the condition of the lungs and the general health of the patient in other respects.

The prognosis of tuberculosis of the larynx is at least always doubtful. In case of prompt and proper treatment the primary form of the disease particularly is curable if the lungs are still unaffected, or existing disease of the lungs is checked and the general health improves. Recurrences are always to be feared. The prognosis is of course most unfavourable when pronounced tuberculosis of the lungs or other organs exists.

The treatment is mainly local, special regard being also paid to the condition of the lungs and the general health (see Principles of Surgery, § 83).

At the beginning the local treatment is essentially the same as in chronic catarrhal inflammation of the larynx (see page 597). Tubercular ulcers are treated by the application on the brush of from twenty-five to fifty or even eighty per cent lactic acid (Krause), by the use of astringents, and by insufflations of iodoform, boric acid, acetate of lead, etc. Inhalation, application, and insufflation of other antiseptic remedies are also very much to be recommended, as they greatly relieve the pain. Carbolic acid, creosote, and balsam of Peru are particularly serviceable. A too irritating form of treatment is to be avoided. The application on a brush of a from five- to ten-per-cent solution of cocaine, or the insufflation of morphine (0·015 grammes once or twice a day), with amylum, iodoform, or boric acid, prove very efficacious in relieving pain. Hypodermic injections of morphine in the vicinity of the larynx are to be recommended. Surgical treatment proper consists in

multiple scarifications, in scraping the ulcers with a small curette, and in subsequent cauterization with lactic acid or the application of iodoform emulsion (M. Schmidt, Hering). If there is extensive disease of the larynx while the lungs are as yet but slightly affected, thyrotomy may be undertaken, with subsequent energetic scraping and cauterization with lactic acid. If there are symptoms of stenosis, tracheotomy is indicated. The use of tuberculin, after R. Koch (see Principles of Surgery, page 421), seems to have led to no permanently favourable results in cases of tuberculosis of the larynx.

Syphilis of the Larynx.—Syphilis of the larynx in the secondary stage of the disease takes the form of a syphilitic catarrhal inflammation with the formation of papules and mucous patches. In the later stages of syphilis inflammatory infiltrations occur, partly as circumscribed gummata (Fig. 309) and partly as diffuse gummatous inflammations of the mucous membrane and the deeper tissues, terminating in ulceration or, it may be, in destruction of the cartilage, with hypertrophy of the connective tissue and the formation of cicatrices.

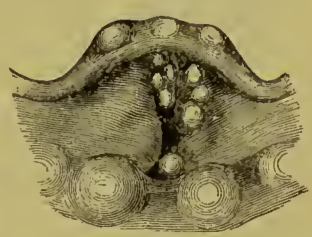


Fig. 309.—Gummata of the larynx (Mandl).

Syphilitic ulcers may occasion great destructive changes very rapidly. Serious disturbances of respiration, making tracheotomy necessary, may ensue from gummatous inflammation, hypertrophy of the connective tissue, and the strictures.

The prognosis of the early symptoms of syphilis of the larynx is favourable in case of prompt antisyphilitic treatment. The gummatous induration and the ulceration attending the later stages of syphilis usually lead to permanent functional disturbances, to defects and strictures. The disease may, moreover, have a latent course for a comparatively long time, and, although far advanced, may cause but few symptoms.

The treatment of syphilis of the larynx should be local, and especially constitutional, by the use of mercury or iodide of potassium (see Principles of Surgery, § 84, page 421). The remainder of the treatment is symptomatic in character. If there is danger of asphyxia in consequence of stricture of the larynx, tracheotomy is indicated. Syphilitic strictures are either divided from within the larynx or from the outside, with the head hanging over the end of the table after partial or complete division of the larynx, tracheotomy having been previously performed. After the division of the cicatricial stricture a Dupuis's canula (Fig. 310) may be introduced for a time. Dupuis's T-shaped canula (Fig. 311) consists of two halves which fit closely

together, and are introduced separately into the trachea and then fastened together by the India-rubber ring at *a* and the screw at *d*. Bougies of hard India rubber or block-tin can be introduced later from within the mouth or through the tracheotomy wound. Patients with syphilitic stricture of the larynx are not infrequently obliged to carry a canula permanently, but the disturbances of speech resulting from this are often very slight.

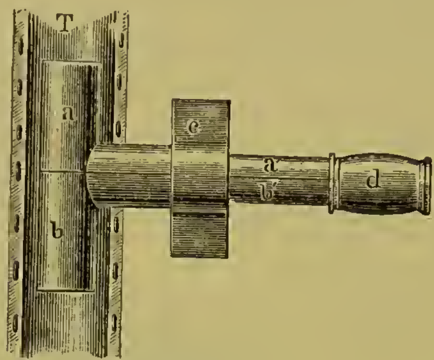


Fig. 310.—Dupuis's canula in position in the trachea (*T*).

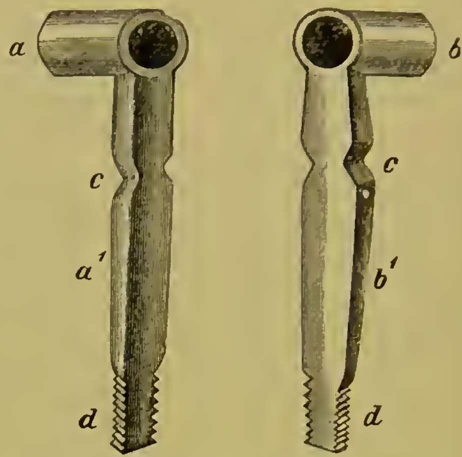


Fig. 311.—The two halves of Dupuis's canula.

Of other ulcers I mention those occurring in leprosy, which arise from a breaking down of the leprous nodules, and the diagnosis of which is made possible by the other symptoms of leprosy which are always present (see Principles of Surgery, § 85). Actinomycosis has also been observed. It is characterized by the fact that enlargement of the lymph glands either does not exist or is only temporary.

So-called lupus of the larynx is a genuine tuberculosis which has a very chronic course..

For a description of carcinomatous ulcerations see page 608.

Inflammation of the Perichondrium and the Cartilages of the Larynx (Perichondritis and Chondritis).—Perichondritis and chondritis of the larynx are either primary—e. g., after injuries or in connection with syphilis or tuberculosis—or, more frequently, a secondary affection following disease of the mucous membrane—e. g., syphilis, tuberculosis, diphtheria, etc. It most frequently attacks the arytenoid and cricoid cartilages.

Inflammation of the perichondrium leads either to induration or to suppuration with separation of the perichondrium and necrosis of the cartilage. The latter may be extensively destroyed, partly from ulceration and partly from the casting off of larger or smaller fragments. In case of non-suppurative perichondritis with induration, marked thickenings may take place with transformation of the cartilage into

connective tissue, or with new growth of cartilage and bone. There is usually inflammatory swelling in the vicinity of the focus in the perichondrium.

The functional disturbances depend in the main upon the situation and extent of the indurative or suppurative inflammation. Symptoms of stenosis arise especially from changes in the form and position of the parts of the larynx, from abscesses (Figs. 312, 313), from indurations and defects with cicatricial contractions, from œdematous swelling of the surrounding parts, and from approximation of the vocal cords—e. g., after paralysis or destruction of one or both posterior crico-arytenoid muscles, etc. If an abscess breaks through externally, emphysema and, finally, an open fistula of the larynx may ensue.

FIG. 312.—Perichondritis of the cricoid cartilage with bulging of the abscess beneath the left vocal cord (Ziemssen).

The course of the affection is always very chronic; acute exacerbations occur, especially from suppuration. Death frequently takes place from asphyxia in consequence of stenosis of the larynx if tracheotomy is not properly performed. If the patient recovers there is usually either more or less permanent induration of the cartilage or cicatricial contraction after the cartilage has been cast off.

The treatment of perichondritis is in general symptomatic, and must depend largely upon the cause of the inflammation. If abscesses are formed they must be incised, and if there is stenosis of the larynx, tracheotomy may become imperative. Among secondary affections, strictures in particular require appropriate treatment by the introduction of laryngeal bougies (catheters of hard India rubber or tin bougies) or intubation tubes. The larynx may be opened in the median line, with the head of the patient hanging over the end of the table (see page 615), and a Dupuis's canula inserted after division of the stricture (see Figs. 310 and 311). Finally, bougies may be introduced into the larynx through the tracheotomy wound. If the stricture is incurable, the patient must carry a canula permanently, or, in case of destruction of the vocal apparatus, an artificial larynx, after Gussenbauer or Bruns (see Fig. 331, page 632).

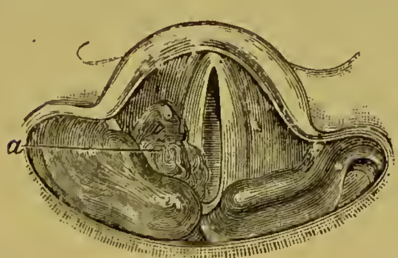


FIG. 313.—Perichondritis of the cricoid and right arytenoid cartilages: *a*, abscess (Türck).

In consequence of extreme lordosis of the cervical segment of the vertebral column compensating kypho-scoliosis of the dorsal vertebræ, pressure ulcers sometimes form on the posterior broad surface of the cricoid cartilage and on the posterior pharyngeal wall, with stenosis of the larynx especially in very emaciated individuals. These ulcers may give rise to necrosis of the entire posterior plate of the cricoid cartilage.

§ 103. **Tumours of the Larynx.**—Of non-malignant new growths in the larynx, the papilloma, adenoma, fibroma, lipoma, angeioma, myxoma, chondroma, and cysts have been most often observed.

Papillomata are most frequent (see Fig. 314)—i. e., warty, villous, or cauliflower-like growths, which correspond to warts and papillomata on the outer skin. They consist chiefly of proliferated and hardened epithelium (pachydermia verrucosa).

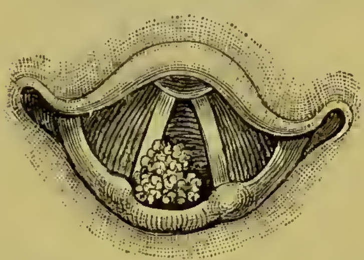


Fig. 314.—Papilloma of the right vocal cord.

According to Werner, the subepithelial connective tissue forms the point of origin of these papillomata, the epithelium participating more or less in the process, depending upon its energy of growth. The epithelium undergoes a change only in quantity and not in quality —i. e., does not become epidermal in character. Chronic irritation (catarrhal inflammation, etc.) is of etiological importance. These papillomata are sometimes single and sometimes multiple, and may be either pedunculated or sessile. Some of the laryngeal polyps are pedunculated papillomata.

The favourite locations of the papilloma are the true vocal cords, the false vocal cords, and the aryteno-epiglottidean ligaments. Epitheliomata of the larynx not infrequently develop from such papillomata through atypical growth of epithelium into the subjacent tissue.

The fibroma also, which consists of connective tissue, with a varying amount of vascularity, occurs sometimes in the form of a sessile growth and is sometimes pedunculated (fibrous polyp). According to Chiari, the fibrous polyps of the vocal cords are mainly simple hypertrophies due to chronic catarrh.

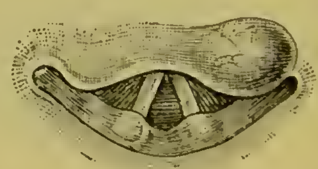


Fig. 315.—Cyst of the epiglottis.

Adenomata, myxomata, lipomata, angeiomata, chondromata, and cysts have been frequently observed. The cysts are really retention cysts of the glands—e. g., on the anterior surface of the epiglottis (see Fig. 315) or in the ventricle of the larynx. Tumours have sometimes been found in the larynx which had their origin in strayed lobules of the thyroid gland (Bruns, Ziemssen).

The symptoms of benign tumours of the larynx are dependent mainly upon their location and size. Changes are observed in the voice, which becomes rough and hoarse, or may be lost altogether. There is also more or less difficulty in respiration, especially in case of large tumours. Patients sometimes say they feel as if there were a foreign body in the larynx.

The prognosis of benign tumours of the larynx is favourable so far as life is concerned. Permanent injury to the voice, however, may remain even after a successful removal of the growths, especially in case of sessile tumours. Recurrences often follow the removal of papillomata, and they not infrequently, as has been said, change into epitheliomata.

The treatment of benign tumours of the larynx consists in their earliest possible removal. This is accomplished either within the larynx or from without after performing laryngotomy. The latter can be performed in various ways: 1. By partial or complete division of the thyroid cartilage (thyrotomy, laryngo-fissure). 2. By dividing the crico-thyroid membrane (infrathyroid laryngotomy), with division of the cricoid cartilage, it may be (cricotomy). 3. By dividing the thyro-hyoid membrane (subhyoid pharyngotomy, Malgaigne, see page 440). Sometimes the entire larynx has to be divided (see also Fig. 320, page 615, Operations on the Larynx). In splitting the thyroid cartilage the division should always be partial when possible—that is, as far as the insertion of the vocal cords, inasmuch as when it is complete, permanent impairment of speech easily ensues in consequence of loss of the point of insertion of the vocal cords. Thyrotomy affords the best access to the interior of the larynx. Division of the crico-thyroid ligament and the cricoid cartilage is especially to be recommended in case of new growths beneath the vocal cords. By pharyngotomy the lower portion of the pharynx and the entrance to the larynx are exposed. In case of tumours of the epiglottis the latter may have to be removed *in toto*. An observation made by Israel and Rosenbaum shows that the complete removal of the epiglottis causes no disturbance in eating, inasmuch as the main protection of the larynx against the entrance of food lies in the fact that the latter enters the œsophagus, not by passing in the median line over the superior aperture of the larynx, but through the pyriform sinuses on the side. Tracheotomy and the insertion of a tampon are often necessary before dividing the larynx, in order to prevent aspiration of blood into the lungs. Or the larynx may be divided with the head of the patient hanging over the end of the table.

The removal of benign tumours from within the larynx is simpler in comparison, and is always to be tried first, tracheotomy being performed beforehand, if necessary, in case of dyspnœa. The intralaryngeal method of operating is done under guidance of the laryngeal mirror after painting the mucous membrane with a from five- to twenty-per-cent solution of cocaine to produce local anæsthesia. The choice of instruments depends upon the nature of the tumour. It is cut off, torn out, or crushed and removed with the instruments repre-

sented in Figs. 316–318, for example, or by means of curved laryngeal forceps and a sharp curette. Tumours are very often destroyed by the galvano-cautery, and sometimes by means of caustic fluids. The intra-laryngeal removal of tumours has become a special art, and the reader

Fig. 316.—Laryngeal knives (Tobold): *a*, blunt pointed; *b*, for cutting upward; *c*, spear pointed.

Fig. 317.—Laryngeal forceps (Oertel).

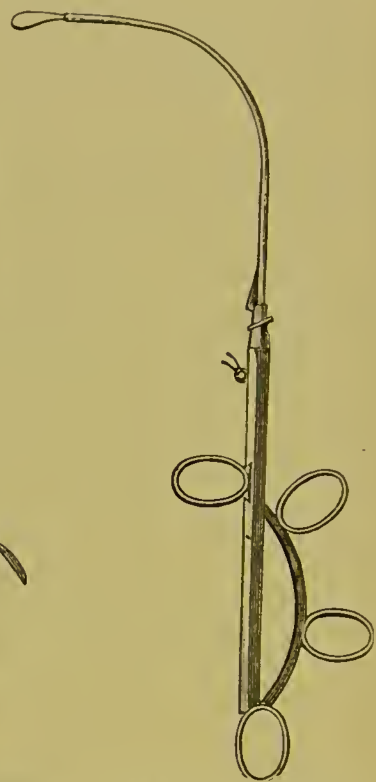


Fig. 318.—Tobold's snare.

must be referred for details of the method to treatises upon laryngology—e. g., those of Türck, Ziemssen, Stoerk, Voltolini, Mackenzie, Fauvel, Gottstein, and others.

Malignant Tumours of the Larynx.—Of the malignant new growths, carcinomata and sarcomata, the former are by far the more common, the latter having been but rarely observed.

Carcinomata of the larynx sometimes develop from papillomata. They are more frequent in men than in women, and occur usually after the fortieth year. Of one hundred and seventy-six patients with this disease, but twenty-nine, according to Wassermann, were women. Habitual drinkers and great smokers seem especially predisposed to laryngeal carcinoma. At the outset the carcinoma either forms papillary growths (Fig. 319), which then penetrate deeper, or more superficial indurations arise, which soon change into ulcers. Progressive

ulcerative destruction is characteristic of carcinoma of the larynx in its later stages. Primary carcinoma of the trachea is very rare and difficult to diagnose and treat.

The symptoms of carcinoma vary according to its location. One usually finds hoarseness, aphonia, pain on speaking and swallowing, hæmorrhages, fœtid secretion, offensive breath in consequence of the ulcerations, swelling of the glands, and indications of stenosis of the larynx, so that tracheotomy finally becomes necessary. The symptoms of primary carcinoma of the trachea are essentially the same as those of carcinoma of the larynx.

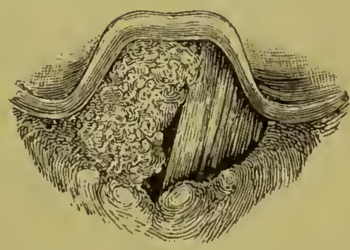


Fig. 319.—Epithelioma of the right vocal cord of one year's duration (Ziemssen).

The prognosis of carcinoma of the larynx is unfavourable. The patient usually dies in from a year to a year and a half. Recovery is possible only in case of prompt extirpation, with excision usually of the half of the larynx that is involved or with its complete removal. I operated on a carcinoma of the larynx eight years ago (thyrotomy, galvano-cautery), and the cure has thus far proved permanent. B. Fränkel obtained a permanent cure in a case of carcinoma by intralaryngeal operation. Unfortunately, most cases of the kind are brought to the surgeon too late, so that a complete cure is seldom observed, as is shown also by recent statistics made by Scheier, Wassermann, and others. According to Wassermann, of one hundred and seventy-six cases of carcinoma treated by complete removal of the larynx, there were but eight in which a permanent cure was obtained (three by Gussenbauer, and one each by Thiersch, Winiwarter, Schede, Fischer, and Bergmann).

The diagnosis of carcinoma of the larynx is based especially upon the laryngoscopic examination. The well-known semispherical, very uneven papillary growths, surrounded by a more or less infiltrated area, are especially characteristic of the disease. If ulceration has already taken place, the ulcers, as opposed to those in erysipelas, for example, are characterized by their uneven base and their raised indurated edges. The infiltration of the surrounding tissue is sometimes more and sometimes less pronounced. The microscopic examination of small portions of the tumour is also important, and, from a differential diagnostic point of view, the observance of other symptoms (swelling of the glands, manifestations of syphilis or tuberculosis).

The treatment of carcinoma of the larynx has yielded as yet few satisfactory results. The earlier an operation is performed the better. In well-advanced carcinoma, resection or complete extirpation of the larynx by Billroth's or Czerny's method is indicated as a rule. After excision of the larynx the patient makes use of some form of artificial larynx, such as that devised by Gussenbauer, Bruns, or J. Wolff (see Fig. 331, page 632). If the patient is brought under treatment

early, one may effect a cure by use of the galvano-cautery after first performing thyrotomy, as, for example, in the case that I operated upon. The number of permanent cures after resection or extirpation of the larynx is very small. The patient almost always dies from recurrence of the disease.

If a radical operation is refused, or if operation is no longer indicated, the treatment is confined to relieving the sufferings of the patient by morphine injections, by applying cocaine, by spraying with disinfecting and deodorizing solutions, and, if necessary, by tracheotomy.

For the technique of resection and extirpation of the larynx, see page 614 ff. (Operations on the Larynx).

Sarcomata of the larynx are rare. They usually form nodular tumours which are marked by rapid growth. Here also the earliest possible extirpation of the tumour with the surrounding tissue—that is, with resection or total extirpation of the larynx—is to be recommended.

§ 104. **Foreign Bodies in the Air Passages.**—The foreign bodies that are found in the air passages—that is, in the larynx, the trachea, and the lungs—are very manifold. Preobrachewsky collected from literature eight hundred and forty-eight cases in which a foreign body was found in the air passages, and ascertained that the most frequent bodies are beans and bones. Foreign bodies in the bronchi give the worst prognosis. The mortality of foreign bodies in the larynx was 39·8 per cent (60·2 per cent recoveries), in the trachea 67 per cent (33 per cent recoveries), and in the bronchi 55 per cent (45 per cent recoveries).

Portions of food, especially bones, fish bones, pieces of meat, etc., very frequently make their way into the larynx, and they are then easily aspirated, particularly when the person speaks while eating. I saw a man choke to death who was very hurriedly eating a German beefsteak. The large morsel was firmly wedged partly in the pharynx and partly in the larynx, and caused death in a few seconds. Death has sometimes been caused by suffocation in consequence of the entrance of vomited material into the larynx during chloroform anæsthesia or in drunken individuals while unconscious. Suffocation may also follow aspiration of blood into the air passages during an operation in consequence of coagulation of the blood. Or the blood which has entered the lungs may become decomposed, and the patient may die from septic pneumonia and general sepsis.

Coins, needles, buttons, gravel stones, peas, beans, fruit stones, artificial teeth, etc., have also been found in the larynx. Buttons, needles, and the like are easily aspirated when they are put between the teeth or into the mouth and the person then laughs or speaks. In one case a physician swallowed in this way a horn shirt-stud, which made its

way into the larynx and bronchus. A long illness followed in consequence of abscess of the lung, and after about a year the button was suddenly coughed up again; but the patient died, in spite of this, of abscess of the lung.

The symptoms attending the presence of foreign bodies in the air passages are variable, depending in part upon the location and the character of the body. Generally speaking, there is always coughing, with more or less dyspnœa. As was said above, immediate suffocation may ensue from the presence of large foreign bodies. There is pain, especially when sharp bodies, such as needles or bits of bone, have become caught in the larynx. Disturbances in speech (hoarseness, aphonia) manifest themselves particularly in those cases in which the movement of the vocal cords is interfered with.

Solid bodies either remain in the larynx, occasioning more or less dyspnœa or fatal suffocation, according to their size, or they make their way into the trachea and the lungs. They may here become encapsulated without reaction, or the microbes upon the foreign body may produce ulceration or an abscess, as in the case above mentioned. If the abscess breaks through the pleura and the wall of the thorax, the body may become discharged externally. Sometimes, as in the case just mentioned, the body is coughed up from the lungs.

Fluid and soft bodies, such as blood, the contents of the stomach, etc., usually pass down as far as the bronchi and set up a pneumonia, or, in case there is a large amount of the material, immediate death from suffocation may ensue.

In order to determine the location of a body in the lung, a careful examination must be made by means of percussion and auscultation. If the body is lodged in a bronchus, one hears on that side diminished breathing only or none at all. In case of abscess of the lung there is dulness on percussion. Râles may be heard chiefly when fluid material is present in the lungs (see Surgery of the Lungs).

The treatment for foreign bodies in the air passages consists in their quickest possible removal. Should this prove impossible, any danger of suffocation that may exist is to be combated by tracheotomy. In the worst cases death takes place before the arrival of a physician. In by far the larger number of cases, however, the body is expectorated by energetic coughing.

Before the extraction of a foreign body from the larynx one must, above all, determine its location by palpation with the finger or by laryngoscopy. Extraction is best performed with a curved laryngeal or pharyngeal forceps after local anæsthesia has been produced by painting the parts with a from five- to ten-per-cent solution of cocaine,

or while the patient is under the influence of chloroform. The latter should be used especially in treating restless children. In case of great dyspnœa, tracheotomy must be speedily performed by dividing the cricoid cartilage and the upper tracheal rings (crico-tracheotomy). Opening the larynx by dividing the crico-thyroid membrane is a very good method, especially when there is danger from delay. In one case, in which the patient was in danger of suffocating when I arrived, I divided the skin and the crico-thyroid membrane at one stroke and saved the nearly moribund patient by artificial respiration. After tracheotomy has been performed an effort should be made to extract the body from within the mouth or through the wound in the trachea. Partial or complete division of the larynx in the median line is sometimes necessary. This is accomplished with the head of the patient hanging over the end of the table. After removal of the foreign body a tracheal tube should be inserted for several days, as symptoms of stenosis may easily arise from œdema of the larynx. We have already mentioned (page 440) that foreign substances may also be removed from the upper part of the larynx by subhyoid pharyngotomy.

If dyspnœa continues after tracheotomy, the body lies in the lower part of the trachea or in the bronchi.

Fluid material in the trachea and in the bronchi is removed by lowering the head and exciting expectoration, and especially by sucking it out by means of an elastic catheter after performing tracheotomy. By lowering the head and by energetic expectoration, solid bodies also may be brought up into the larynx and here extracted, or, it may be, coughed out. If the foreign body has descended into a bronchus, one should perform low tracheotomy and try to extract the body, or to make the patient bring it up by violent coughing. F. Willard, in experimenting on dogs, tried to remove foreign bodies, such as small stones artificially placed in the bronchi, by opening the bronchus (bronchotomy). He succeeded, however, very rarely even in finding the foreign body. In case an abscess of the lung forms and is accessible, one may remove the encapsulated body by incision.

§ 105. **Neuroses of the Larynx.**—We shall here speak briefly of neuroses of the larynx only in so far as they produce stricture of the larynx and thus give occasion for the performance of tracheotomy. A distinction is made, as is known, between sensory and motor neuroses. Regarding the former—viz., hyperæsthesia, anæsthesia, and paræsthesia of the laryngeal mucous membrane—the reader is referred to treatises upon internal medicine or laryngology. Motor disturbances interest us especially, and, both in the form of spastic conditions and paralyses, are of great significance for every physician.

We mention first spasm of the constrictor muscles of the glottis, or laryngeal spasm, which leads to attacks of convulsive closure of the glottis, and is caused by direct or reflex stimulation of the recurrent laryngeal nerve or the pneumogastric nerve above the point of origin of the former (see also page 592, Nerves of the Larynx). Laryngeal spasm is most frequently observed in weakly children from six months to two years old; occasionally also in adults with catarrhal inflammation, or in connection with emotion, hysteria, or epilepsy, or from irritation of the recurrent laryngeal nerve or of the pneumogastric above the point of origin of the former—e. g., from pressure on the same by tumours, aneurisms, etc. The attack is characterized by apnœa, which appears suddenly and is of short duration. The number and intensity of the attacks are very variable. The prognosis is not unfavourable. With better nourishment and the removal of other causes recovery usually ensues. Death has occurred, however, during such an attack, but this is exceptional. In adults it amounts usually to nothing more than sibilant inspiration with short, loud expiration.

The treatment is directed, above all, against the cause. During the attack itself one throws cold water into the face, causes the patient to inhale ether or chloride of ammonium, makes use of cold showers, etc. In serious cases a rubber catheter should be introduced into the trachea, air insufflated, and artificial respiration maintained in the usual way (see Principles of Surgery, § 13, page 34). The duration of the attacks is shortened by inhalation of chloroform. Bromide of potassium or bromide of soda is given internally. The use of electricity is frequently indicated.

Of other neuroses of the motor apparatus I mention two disturbances of co-ordination with defective action of the vocal cords. The latter do not obey the will, and instead of an intended action, one that is not intended is executed. In this category belongs the functional spasm of the rima glottidis—that is, a convulsive contraction of the constrictor muscles of the glottis attends every attempt at phonation, so that in extreme cases the patient is for the time being completely speechless.

Another form is the inspiratory spasm of the rima glottidis, in which the glottis is not dilated as is normally the case, but is closed by spasmodic contraction of the constrictor muscles. Death has not as yet been known to occur from the two last-mentioned forms of spasm of the rima glottidis.

The etiology of this phonic and inspiratory spasm of the rima glottidis is as yet obscure. The number of cases that have been observed is still small, and in these there were central or peripheral nerve disturbances, and especially paralysis of certain nerves of the larynx.

The paralysis of certain laryngeal muscles is caused either by disease of the central nervous system (hysteria, bulbar paralysis, tabes, progressive muscular atrophy, etc.) or by disturbances of the peripheral nerves—viz., the superior laryngeal, the recurrent laryngeal, the pneumogastric, and the spinal accessory (see also page 592, Nerves of the Larynx). Primary myopathic paralysis is more rare.

Of the single paralyses of the laryngeal muscles I mention especially the following:

1. Paralysis of the crico-thyroid muscle, which increases the tension of the vocal cords and is supplied by the superior laryngeal nerve. This is

characterized particularly by a rough, deep voice, which is incapable of giving the high tones. There is no case as yet in the literature of the subject of isolated paralysis of this muscle (Gottstein). In case of bilateral paralysis of the superior laryngeal nerve, closure of the larynx is interfered with, and the latter is, moreover, anæsthetic. Death may therefore occur from aspiration pneumonia resulting from the entrance of food into the air passages.

2. Paralysis of the muscles that close the glottis (crico-arytenoidei laterales, arytenoideus transversus, thyro-arytenoideus externus and internus muscles, all of them supplied by the recurrent laryngeal nerve). There is inability to close the glottis.

3. Paralysis of the muscle that opens the glottis (the crico-arytenoideus posticus, supplied by the recurrent laryngeal nerve). This paralysis is directly dangerous to life, especially when both vocal cords are paralyzed, so that they lie more or less adjacent to each other, and the rima glottidis is still further closed with every inspiration. There is dyspnœa, therefore, only during inspiration, as a rule, expiration being free. Death may very easily occur from asphyxia if tracheotomy is not promptly performed. In case of unilateral paralysis the breathing is usually not impeded, as the glottis is sufficiently wide. Upon laryngoscopic examination, one sees the paralyzed vocal cord, or both cords are nearer the median line and immovable during phonation.

4. Paralysis of all the muscles supplied by the recurrent laryngeal nerve —that is, all the muscles of the vocal cords with the exception of the crico-thyroid muscle, which is supplied by the superior laryngeal. In this form of paralysis the openers and closers of the glottis are paralyzed, and in bilateral paralysis the vocal cords are immovable and in the so-called cadaveric position (see page 591, Fig. 299).

The diagnosis of these paralyses is made by laryngoscopic examination. It is not difficult if one is familiar with the function of the individual muscles. Patients with paralysis of the vocal cords usually have a characteristic garlic-like breath, in consequence of stagnation and decomposition of the secretion of the mucous membrane in the vicinity of the paralyzed cord, so that from this one can make the diagnosis of at least a probable paralysis of the vocal cords (Fauvel).

The treatment is directed chiefly against the cause. It consists, in addition, in proper local treatment, in the application of electricity, the administration of strychnine, etc. Tracheotomy is necessary, especially in case of bilateral paralysis of the openers of the glottis.

§ 106. **Operations on the Larynx and Trachea.**—As we saw (page 440), Malgaigne's subhyoid laryngotomy with transverse division of the thyro-hyoid membrane (Fig. 320 I) is more properly designated as subhyoid pharyngotomy, because it is not the larynx but the lower part of the pharynx that is opened. (For the technique of subhyoid pharyngotomy, see page 440.)

The operations on the larynx and the trachea are: 1. Partial or complete division of the thyroid cartilage (thyrotomy, see Fig. 320 II).

2. Division of the crico-thyroid membrane (infrathyroid laryngotomy, Fig. 320 III), with division, if necessary, of the cricoid cartilage (cricotomy, Fig. 320 IV). Sometimes all of the above-named parts of the larynx are divided. All operations in which the larynx is opened are included under the name laryngotomy, which may involve either a partial or a complete division of the larynx. 3. Tracheotomy, either in the form of high tracheotomy, above the isthmus of the thyroid gland, with division of the upper rings of the trachea (Fig. 320 V), with or without cricotomy, or as low tracheotomy below the isthmus of the thyroid gland (Fig. 320 VI). If, in connection with high tracheotomy, the cricoid cartilage is also partially or wholly divided, the operation is called crico-tracheotomy. 4. As the last operations upon the larynx, its resection and complete extirpation are to be added.

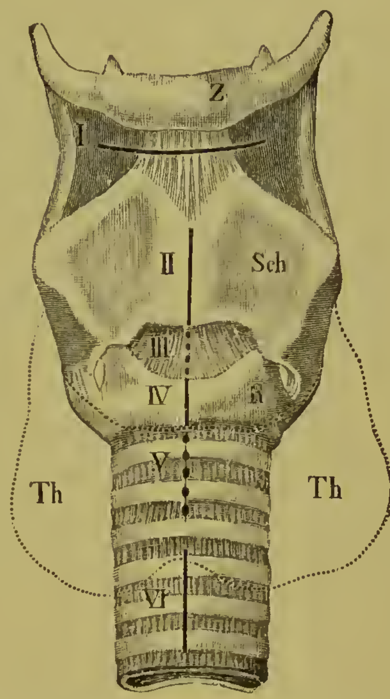


Fig. 320.—Operations on the larynx: *Z*, hyoid bone; *Sch*, thyroid cartilage; *R*, cricoid cartilage; *Th*, outline of the thyroid gland; *I*, subhyoid pharyngotomy; *II*, thyrotomy; *III*, infrathyroid laryngotomy; *IV*, cricotomy; *V*, high, and *VI*, low tracheotomy.

I. **Thyrotomy.** — Partial or complete division of the thyroid cartilage (Fig. 320 II), thyrotomy, is performed for fractures of the cartilages of the larynx, especially the thyroid cartilage, for the extraction of foreign bodies, for inflammations and strictures of the larynx, for the extirpation of laryngeal tumours, for the radical treatment of laryngeal tuberculosis, and finally in connection with resections of the larynx or the thyroid cartilage. The operation is wholly free from danger so far as life is concerned. If the entire thyroid cartilage is divided, permanent functional disturbances of the voice may follow. If possible, one should divide only the lower part of the thyroid cartilage, and leave the point of insertion of the vocal cords intact.

Thyrotomy is performed either with the head of the patient hanging over the end of the table, or with a roller cushion laid beneath the nape of the neck or under the shoulders, so that the head is bent backward and the anterior region of the neck is made prominent. Tracheotomy—low tracheotomy, if possible—is often a necessary preliminary to thyrotomy, and the trachea may then be tamponed. Pieniazek, who has had a wide experience, recommends cricotomy as a pre-

liminary operation—i. e., he divides the cricoid cartilage and crico-thyroid membrane, does not use the tampon, but always opens the larynx with the head of the patient hanging over the end of the table immediately after the performance of tracheotomy.

The incision through the skin runs exactly in the median line of the neck, and, in case of complete division of the thyroid cartilage, from the lower border of the hyoid bone to the upper border of the cricoid cartilage. If the lower part of the larynx, the crico-thyroid membrane, and the cricoid cartilage are also to be divided, the incision through the skin should be carried still farther downward, and one must be on the lookout for the horizontal anastomosis of the two cricoid arteries over the crico-thyroid membrane. One must also bluntly detach the thyroid gland from the cricoid cartilage in case the former extends far upward, just as is done in high tracheotomy (see page 618).

The division of the cricoid cartilage must be made exactly in the middle line, which is recognised by a white line (linea alba cervicis) in the superficial fascia, extending from the sternum to the thyroid cartilage and the hyoid bone. The division of the fascia follows this line, and the fascia is retracted on each side together with the soft parts. The crico-thyroid membrane is divided at the lower border of the thyroid cartilage by a small transverse incision, without cutting the cricoid arteries and the crico-thyroid muscles, and then at first only the lower part of the thyroid cartilage is divided. This division is made exactly in the middle line, and is best performed by inserting the point of the knife and cutting from within outward. If the cartilage is calcified or ossified, it is divided with strong scissors or with Liston's bone-cutting forceps. One should, if possible, as has been said, leave the upper border of the thyroid cartilage, at the point of insertion of the vocal cords, intact. If the entire thyroid cartilage is to be divided, great care must be taken not to injure the insertion of the vocal cords. The better way is to divide the upper part of the thyroid cartilage upon a grooved director from within outward, exactly in the median line, by means of a probe-pointed knife. The interior of the larynx can now be sufficiently exposed for any operation that is to be undertaken within the larynx by drawing apart the halves of the thyroid cartilage. It is often necessary, however, to detach the crico-thyroid membrane, the thyro-hyoid ligament, and the thyro-hyoid membrane laterally on the upper and lower borders of the thyroid cartilage, in order to be able to draw the halves of the thyroid cartilage farther apart, and thus to gain still better access to the interior of the larynx. If the larynx has been opened on account of an intralaryngeal tumour, it is a good plan, after

removal of the growth—a papilloma, for instance—to keep the larynx open by packing it for about two days, and then carefully to examine the laryngeal cavity once more, to determine whether there are still diseased places, new growths, etc., which require treatment. In the after-treatment, especially of a stricture, it is a good plan to insert an intubation tube or a Mikulicz's glass tube.

Laryngotomia Transversa.—Gersuny, after first performing tracheotomy, has opened the larynx between the true and false vocal cords in place of subhyoid pharyngotomy or ordinary laryngotomy. After division of the skin in the median line from the hyoid bone to the cricoid cartilage, and separation of the soft parts from the alæ of the thyroid cartilage, the latter is severed transversely above the vocal cords just below the notch with a metacarpal saw or scissors, and finally the mucous membrane is divided with the scalpel.

II. **Infrathyroid Laryngotomy and Cricotomy.**—Infrathyroid laryngotomy (Fig. 320 III) means the division of the crico-thyroid membrane, and provides but little room for intralaryngeal operations. Usually, therefore, the cricoid cartilage is divided at the same time (cricotomy) (Fig. 320 IV) for the treatment of strictures, for example, in the lower part of the larynx, or for the removal of granulations after tracheotomy. This operation is performed in the same way as thyrotomy—that is, by placing a roller cushion under the nape of the neck, or with the head hanging over the end of the table.

The incision through the skin begins over the centre of the thyroid cartilage and runs downward over the cricoid cartilage. The crico-thyroid membrane is exposed in the space between the sterno-hyoid, sterno-thyroid, and crico-thyroid muscles, and then, after ligation of the cricoid artery on both sides, longitudinally or transversely divided. If the cricoid cartilage is also to be divided in the median line (cricotomy), it is exposed by detaching the isthmus of the thyroid gland and drawing it downward (see page 618, Tracheotomy).

In adults, by a longitudinal division of the skin and the crico-thyroid membrane with a single stroke of the knife, one can open the larynx very quickly in urgent cases of laryngeal stenosis, or for the purpose of artificial respiration, and this form of laryngotomy may consequently be used as a substitute for tracheotomy. In children, however, this space is too small, and it would be necessary to divide the cricoid cartilage as well. The hæmorrhage from the transverse anastomosis of the crico-thyroid arteries should be arrested by a deep suture or ligature.

The after-treatment following thyrotomy, infrathyroid laryngotomy, and cricotomy is determined by the existing disease which made

the opening of the larynx necessary. One usually closes the upper part of the wound in the larynx in the neighbourhood of the insertion of the vocal cords, for example, and in case of complete division of the larynx one inserts a tracheal tube into the lower angle of the wound, as laryngeal stenosis easily results from secondary swelling of the mucous membrane. The larynx and trachea are often packed with iodoform gauze above the tracheal tube—e. g., after scraping the larynx and cauterizing it with lactic acid for tuberculosis.

III. **Tracheotomy.**—Tracheotomy (Fig. 320 V and VI) is indicated for the most varied forms of laryngeal stenosis, for foreign bodies, injuries, inflammations, strictures, tumours of the air passages, paralyses of the vocal cords, compression of the larynx and the trachea from without, for the performance of artificial respiration in cases of asphyxia, etc. All these indications for tracheotomy have been sufficiently dwelt upon in speaking of injuries and diseases of the neck, the larynx, and the trachea. We have likewise mentioned that in connection with various operations in the oral and pharyngeal cavities, as well as in the larynx, preliminary tracheotomy, and tamponing the larynx or trachea, are not infrequently necessary to prevent aspiration of blood into the air passages or into the lungs.

The History of Tracheotomy.—Tracheotomy was performed even in ancient times, and especially from the sixteenth century on. It was resorted to chiefly for foreign bodies. At the beginning of the nineteenth century Caron tried in vain to bring the operation into practice in connection with diphtheria. Bretonneau, in Tours (1818–1862), A. Trousseau (Paris. 1801–1866), Guersant, and others were the first who succeeded in this. We are especially indebted to Baum, Roser, and Passavant for the introduction of tracheotomy in Germany in treating croup and diphtheria. Baum was the first in Germany to perform it successfully. This was in Greifswald in 1844. It was not generally introduced in England in connection with croup and diphtheria until later.

A. High tracheotomy above the isthmus of the thyroid gland, with or without division of the cricoid cartilage (cricotomy or crico-tracheotomy), is performed as follows:

By means of a roller cushion placed under the nape of the neck or under the shoulders the head is inclined well backward, or it may be allowed to hang over the end of the table. In this way the larynx and the trachea are drawn sufficiently forward and upward. To recognise the different portions of the larynx, one feels for the pomum Adami with the notch in the upper border of the thyroid cartilage, then the crico-thyroid membrane follows as a gap between the thyroid and cricoid cartilages, and then comes the cricoid cartilage. The

incision through the skin begins about a finger's breadth above the cricoid cartilage and passes downward three or four centimetres in children and four or five centimetres in adults, following the median line of the neck. After division of the skin a white longitudinal band of the cervical fascia is noticeable in the median line of the neck between the sterno-hyoid muscles, which should be thoroughly exposed. This white line is now split in its whole length. If the sterno-hyoid muscles are then drawn to one side by means of blunt retractors, or, if no assistant is present, by means of Bose's double retractor (Fig. 321), one finds, in the upper part of the wound, the crico-thyroid membrane and the cricoid cartilage, and feels the isthmus of the thyroid gland farther down. The thyroid gland very frequently extends abnormally high. To expose the cricoid cartilage and the upper tracheal rings, one divides the laryngeal fascia, under normal conditions, by a transverse incision upon the cricoid cartilage, detaches from the trachea by means of a grooved director the thyroid gland which lies between the two layers of the laryngeal fascia, and has it held downward by means of a broad retractor. The trachea is now exposed, but before it is opened all hæmorrhage in the wound must be carefully arrested. In order to fix the trachea and draw it forward, a tenaculum may be introduced into the upper edge of the cricoid cartilage near the middle line, but this is not necessary. The trachea is now divided exactly in the median line, from the lower edge of the cricoid cartilage downward, corresponding to the two, three, or four upper tracheal rings, by inserting a sharp-pointed knife perpendicularly and not too deeply. To avoid injury to the posterior tracheal wall, the puncture in the trachea may be enlarged with a probe-pointed bistoury. I do not usually divide the cricoid cartilage. After opening the trachea I never fail to pass a silk suture through its edges on both sides by means of a curved needle, and to secure these sutures by a band about the neck. These sutures allow an easy inspection of the trachea, aid the introduction of the tube, and are of advantage in the after-treatment, especially for changing the tube.

Fig. 321.—Bose's self-retaining retractor.

Fig. 322.—Retractor for drawing down the thyroid gland.

After the operator has convinced himself that the patient breathes freely and has removed any croupous or diphtheritic membranes that there may be, or other obstacles—e. g., blood and mucus—by sucking

them out with an elastic catheter or an aspirating syringe, the tube is introduced. After its introduction one must satisfy himself that it is properly situated in the trachea and that respiration through it is unimpeded. The tube is secured by means of a band about the neck. Luer's tube, which has been modified in a practical way by Hagedorn (Fig. 323), is especially to be recommended. It consists of a double silver tube whose inner tube (B) can be easily removed from the outer one (A). The outer tube is furnished with a movable shield, so that the whole can easily follow the respiratory movements of the trachea. The inner tube is fastened by means of the small adjustable clasp (C) upon the shield. In an emergency an India-rubber tube or the end of an elastic catheter can be used in place of a tracheal tube.

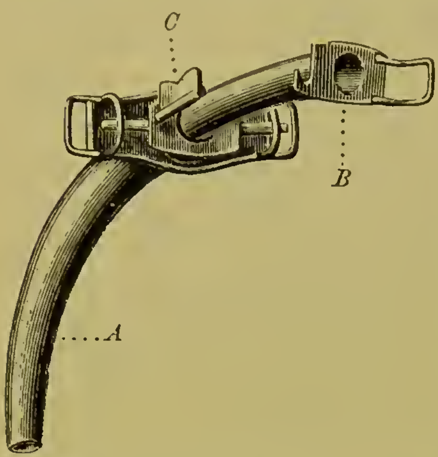


Fig. 323.—Luer's tracheal tube as modified by Hagedorn: *A*, outer, and *B*, inner tube; *C*, clasp for holding the inner tube.

If there is a deeply seated stenosis of the trachea—e. g., from compression of the trachea by a substernal goître—König's long tracheal tube is serviceable, which is movable at its lower part in consequence of its spiral structure (Fig. 324 and Fig. 298, page 588). Kocher and Salzer have also recommended a serviceable tracheal tube for patients with goître (see page 588).

Zaleski has called attention to the occurrence of argyria from the use of silver tracheal tubes, and has therefore recommended that they be made of platinum, gold, rock-crystal, glass, porcelain, or ivory. Roser recommends the use of tracheal tubes which are wrapped with iodoform gauze. They usually lie for two days, and are then replaced by a similar tube. Superficial gangrene, granulations, and the entrance of mucus and blood into the lungs, are said to be prevented by these tubes, and it is possible that the spread of diphtheritic processes is also checked.

Fig. 324.—König's tracheal tube.

As regards packing the opened trachea after Langenbuch, see page 628. In all cases in which there is no time to lose it is possible in adults, as was said above, to divide the crico-thyroid membrane and the skin in one stroke with a sharp-pointed knife. In children the cricoid cartilage must also be divided, to gain sufficient room for a tracheal

tube. The hæmorrhage from the transverse anastomosis of the two crico-thyroid arteries should be arrested by pressure with the finger, and then by means of artery clamps or a deep suture.

The instrument constructed especially for tracheotomy—e. g., the tracheotome—by means of which it is intended that the operation be performed by a single puncture, should be discarded. The same is true regarding the use of the galvano-cautery or the thermo-cautery.

B. Low tracheotomy below the isthmus of the thyroid gland (Fig. 320 VI) is performed as follows:

The position of the patient is the same as in high tracheotomy.

The incision through the skin is exactly in the median line of the neck from the lower border of the cricoid cartilage nearly to the upper border of the sternum. After dividing the skin, the subcutaneous cellular tissue, and the superficial fascia, one works his way in between the sterno-thyroid muscles through the connective tissue, which is well supplied with veins. If necessary, the lower border of the isthmus of the thyroid gland is drawn upward. After blunt division of the loose connective tissue that lies in front of the trachea by means of two thumb forceps, a probe, or the handle of a scalpel, the trachea lies exposed. In doing this, one should be aware of the fact that, as a rare exception, the common carotid artery, especially on the right side, may cross the trachea in consequence of an abnormal origin from the common carotid of the other side. The possibility of the existence of an arteria thyroidea ima must also be borne in mind. After drawing the trachea forward by means of a tenaculum, it can easily be opened. One must here be on his guard against injury to the innominate artery, which may be protected by introducing the forefinger into the lower angle of the wound before incising the trachea. The head must be somewhat raised when the tracheal tube is introduced, as otherwise the posterior and anterior walls of the trachea are in too close proximity.

Low tracheotomy is especially indicated when a hypertrophied thyroid gland extends far upward; also as a preliminary to resection and extirpation of the larynx in order, by packing the trachea, to prevent a flow of blood into the air passages. Several surgeons—Wilms, for example—prefer low tracheotomy for all cases.

For tracheotomy in case of goître, see page 588. The point at which the opening into the trachea is to be made depends upon the nature of the case.

Serious accidents in connection with tracheotomy are rare when the operation is properly performed. Children who are operated upon as a last resort not infrequently die while under the influence of the anæsthetic or in consequence of the loosening of pseudo-membranes which

become lodged below the tracheal tube in the region of the bifurcation. Death has also been observed repeatedly in consequence of the entrance of air into the veins. We have already alluded to the possibility in low tracheotomy of injury to the innominate artery or to the common carotid, in case it has an abnormal origin.

The after-treatment following tracheotomy consists in dusting the wound with iodoform, in laying a strip of iodoform gauze beneath the shield of the tracheal tube, and then, particularly, in the intelligent care of the patient by some trained person. Care must be taken, above all, that the tube does not become obstructed, and that the air of the room is not too cold or too dry. The wound and the tracheal tube should therefore be covered with moist gauze or with a pervious warm sponge, and the air of the room kept moist by steam spray, by inhalation apparatus, or by hanging up pieces of linen which have been moistened with one to two per cent carbolic acid. The nourishment of the patient should consist of nutritious fluids, and wine is especially to be recommended. To keep the tracheal tube pervious, it is not sufficient simply to remove and cleanse the inner tube from time to time, but the outer tube also must be entirely removed occasionally to clear away the crusts of secretion that frequently form at the lower end.

Secondary Diseases following Tracheotomy.—In consequence of diphtheritic paralysis of the palatine muscles and of the sensory nerves of the superior aperture of the larynx, the fluids that are swallowed frequently pass through the larynx into the trachea and out through the wound in the latter. This paralysis usually disappears spontaneously before long. It is better to confine the diet to milk and wine. In severe cases of this form of paralysis, nourishment has to be given through the œsophageal tube and by nutritive enemata.

After diphtheria, the tracheotomy wound not infrequently becomes diphtheritic. This wound diphtheria has a favourable prognosis. It is treated in accordance with the rules given in Principles of Surgery, § 72, page 353.

Secondary hæmorrhages sometimes occur in the course of the after-treatment. They come either from the wound or the tracheal mucous membrane, and the patient may quickly bleed to death in consequence, or blood may flow into the lungs and cause suffocation. Secondary hæmorrhages resulting from erosion of the innominate vein, the common carotid artery, the internal jugular vein, and the innominate artery from pressure of the tracheal tube after low tracheotomy, or in consequence of suppuration, etc., are also worthy of mention (Körte, Gnändiger, Bayer, Frühwald, F. Ganghofner, Maas). This complication occurs, almost without exception, in cases of low tracheotomy. These fatal secondary hæmorrhages sometimes originate in the lungs.

Emphysema sometimes occurs in the vicinity of the tracheotomy wound in consequence of the entrance of air into the surrounding connective tissue. This emphysema is usually slight and without special significance.

One form of emphysema, on the other hand, occurring in connection with severe cases of diphtheria, has an unfavourable prognosis. It may be very extensive, and probably has its origin, according to Virchow and P. Güterbock, in the interlobular connective tissue of the lungs.

Moreover, the prognosis of the cutaneous emphysema that results from the formation of gases in connection with wound diphtheria is also unfavourable.

The tracheal tube is kept in place until the cause of the tracheotomy—laryngeal stenosis from diphtheria, for example—has been removed. The earlier the tube is taken out the better. In diphtheria, one can often remove it from time to time as early as the second or third day. It is usually removed permanently on from the fourth to the eighth day, according to the nature of the case. Broca, Büngner, and others have recommended for after-treatment a special tracheal tube with an opening which has a closing slide over it, so as to allow the gradual return to normal breathing and to avoid accidents from asphyxia. After removal of the tube complete healing of the tracheal wound usually takes place in a few days. The removal of the tube has to be sometimes delayed, especially in long-continued diphtheria with a continuous formation of pseudo-membranes, in relapsing diphtheria, in subacute and chronic swelling of the mucous membrane in the vicinity of the vocal cords and usually beneath them (chorditis inferior), in case of retention of catarrhal secretion in the trachea and in the bronchi (Hagenbach–Burckhardt), in case of relaxation of the anterior tracheal wall or a bend in the trachea, in case of compression of the trachea from without, in paralysis of the vocal cords, spasm of the glottis, and most frequently in case of granulations and of strictures from various causes. In all such cases where the removal of the tube is necessarily delayed it is a good plan to examine the larnyx and trachea by means of a mirror through the tracheal wound.

Paralysis of the vocal cords is usually characterized by aphonia. It disappears, as a rule, spontaneously, like other forms of diphtheritic paralysis. Electrical stimulation of the muscles of the vocal cords is only indicated when the affection continues for a long time (see Paralysis of the Vocal Cords, pages 613 and 614).

Granulations, which are by far the most frequent cause of difficulty or delay in the removal of the tracheal tube, sometimes form after tracheotomy. They always result from tracheotomy itself and not from the diphtheritic process. They are always found on those parts of the trachea which have been in contact with the tube, and most frequently in the tracheal wound itself. They occur much less frequently on the anterior or posterior tracheal wall, where the lower end of the tube or its convex curve lies in contact with the wall of the trachea. The granulations on the posterior tracheal wall are particularly likely to follow the use of the phonation tubes, by whose opening for speaking the infiltrated mucous membrane is irritated and eroded so that an ulcer is formed. The formation of granulations is sometimes so abundant that they surround the tube within the trachea. If the tube is then removed, the mass of granulations closes not only the outer wound, but also the lumen of the trachea, like a valve, and dangerous asphyxia ensues, so that the tube has to be immediately introduced again. In other cases we have to do with polypous growths.

The treatment of granulations consists in enlarging the wound in the trachea above and below, with the head of the patient hanging over the end of the table, and then removing the granulations with scissors and thumb forceps, or with a sharp spoon or the galvano-cautery.

Ulcers sometimes form in the trachea, as has already been mentioned, from the pressure of tubes that are not suitably curved, which, aside from the formation of granulations, may also give rise to hæmorrhage into the bronchi, with attacks of suffocation, or even death from suffocation. These ulcers are most frequently found on the anterior wall, such being the case in sixteen cases, for instance, out of twenty-two tabulated by Schüller. Ulcers on the posterior wall of the trachea may occur, as has been said, in consequence of friction from the opening in the phonation tubes, whose use is not at all to be recommended.

Any cicatricial strictures that may remain after tracheotomy are to be treated in accordance with the rules given on pages 603–607.

IV. **Intubation of the Larynx.**—An attempt has been made, in treating croup and diphtheria attended with laryngeal stenosis, to replace tracheotomy by the so-called intubation of the larynx. By this intubation is understood the introduction for a certain period of metallic tubes into the larynx from within the mouth. These tubes are not round, but are oval on cross-section. They are so constructed that they remain in place within the larynx, and thus secure undisturbed respiration in croupous and diphtheritic laryngeal stenosis.

The idea of intubation, or "tubage," of the larynx originated in France, where Loiseau and Bouchut vainly tried to introduce the method into practice. Recently intubation of the larynx has been widely extended through the efforts of an American physician, O'Dwyer, of New York, and it has been used there in place of tracheotomy, especially in the treatment of croup and diphtheria. The method was first tried in Germany by Thiersch, Rehn, and others. The results are, generally speaking, neither better nor worse than those attending tracheotomy. According to Dillon Brown, of 806 cases of diphtheria treated by intubation, the recoveries amounted to 27·4 per cent, and according to Waxham, of 1,072 patients thus treated, 287, or 26·77 per cent, recovered. Of 697 patients upon whom tracheotomy has been performed in the last ten years in the Leipsic clinic, 24·5 per cent recovered. Among Hagedorn's 572 tracheotomies, 44·75 per cent recovered. The latest American statistics collected by McNaughton and Maddern show among 5,546 cases of intubation 1,691 recoveries (30·5 per cent). The statistics collected by the Deutsche Gesellschaft für Kinderheilkunde (2,500 intubations) seem to show that intubation has accomplished better results in children during the first two years of life. During the first year of life 13·9 per cent recovered after intubation and only 5·4 per cent after tracheotomy; in the second year, 32·3 per cent after intubation and 25·4 per cent after tracheotomy (Ranke). As is well known, the mortality attending diphtheria varies greatly according to the character of the epidemic, ranging anywhere from

fifty to ninety per cent. The good results which American physicians have secured by intubation may be explained, perhaps, by the circumstance that, according to their reports, diphtheria takes a milder form in America. This has also been emphasized by Ranke. Intubation has been much used recently in Europe and especially in Germany, particularly by physicians, less by surgeons, and as greater familiarity with the technique has been acquired, the results have been decidedly better (Ranke, Bókai, Ganghofner, Muralt, and others).

The instruments used in intubation are a mouth gag, tubes of different sizes according to the age of the child, an introducer, and an extractor, by means of which the tubes are introduced into and removed from the larynx. The metallic tubes rest with their bulging portions upon the false vocal cords and reach down below the cricoid cartilage. Before the tubes are introduced they are provided with a thread, that they may be easily withdrawn again in case, for example, they are not in proper position. The mouth of the child is held open by means of a mouth gag. The superior aperture of the larynx or the arytenoid cartilages are felt for with the forefinger of the left hand, and the tube is quickly carried upon the introducer into the larynx. The technique, both of introduction and extraction of the tubes, may be quickly acquired on a larynx fastened upon a plate of cork (Heubner). After proper introduction of the tube into the larynx, which must be done carefully and without using any force, the thread may be removed, to prevent the child from pulling at it. Others allow the thread to remain, so as to be able at any time to remove the tube easily. The loop is fastened to the cheek by means of adhesive plaster. The effect of the introduction of the tube is surprising. The laryngeal stenosis is remedied at once. If dyspnœa continues, either the tube is not in the larynx, but in the œsophagus, or it may lie properly, but is obstructed, or a diphtheritic membrane has been pushed downward by the tube, which closes it like a valve. The dislodgment of false membranes is very dangerous, but, fortunately, it is of rare occurrence. Membranes that have been pushed down in this way could perhaps best be removed with a curved wire loop such as Roser used for the extraction of foreign bodies from the bronchi. Under normal conditions one may allow the tube to lie for some days without its causing any trouble—e. g., at most three days—and its introduction a second time is often unnecessary. O'Dwyer has recommended changing the tube for the first time after forty-eight hours, and then every twenty-four hours. Superficial erosions resulting from

Fig. 325.—Intubation tubes.

pressure have been occasionally observed only in those places which were in contact with the edges of the tube, but no deeper necrosis occurs. An intubated child must be carefully watched by the physician, as danger of suffocation may suddenly arise, owing to membranes and to obstruction of the tube, and the latter may also be coughed out. This danger of suffocation is greater in intubation than in tracheotomy. The chief disadvantage of intubation is the fact that the children often can not swallow liquids well, and that particles of solid food also are sometimes aspirated, causing aspiration pneumonia. It often happens, therefore, that the children have to be fed through a soft catheter passed through the nose into the œsophagus. Carsten's modified tube, shown in Fig. 325, facilitates swallowing by allowing the epiglottis, during the act of swallowing, to cover the end of the tube more perfectly.

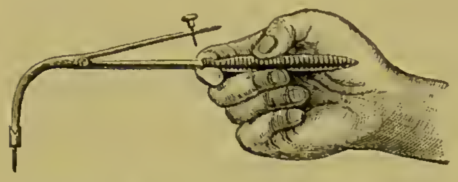


Fig. 326.—Extractor for the removal of intubation tubes.

Waxham constructed a metallic epiglottis for the upper end of the tube in the form of a movable metallic cover, to prevent swallowing the wrong way. The tube has sometimes been swallowed and has been passed *per rectum* without occasioning any trouble. Supplementary tracheotomy is not infrequently found necessary on account of increasing asphyxia in children who have been intubated. The prognosis of this secondary tracheotomy is very unfavourable.

From the observations that have thus far been made, the following are especially to be mentioned as possible disadvantages or dangers of the method, aside from the difficulties in after-treatment which have already been spoken of: Injury to the larynx, a false passage, erosions of the larynx, obstruction of the tube, slipping of the tube into the trachea or the œsophagus, coughing the tube out, asphyxia resulting from swelling of the mucous membrane at the entrance to the larynx, pushing down membranes, aspiration pneumonia, etc. Intubation will not succeed, judging from past experience, in supplanting tracheotomy in the treatment of diphtheria. I agree with Krönlein, Schlatter, and others in the opinion that tracheotomy is and will remain the best method for the treatment of diphtheritic laryngeal stenosis. Intubation, as has been

Fig. 327.—Introducer carrying a tube.

said, is used chiefly by physicians and less by surgeons. Its great and unquestionable advantage is the rapidity with which it can be done, and the fact that it can be performed without inflicting a wound. It is absolutely contraindicated when diphtheria is complicated with gangrene, nor is it applicable in case of œdema of the glottis or stenosis very low down. Owing to the difficulties in after-treatment, intubation is not adapted to use in private practice, but only in hospitals where there are trained attendants. The method is to be recommended highly in cases of chronic stenosis of the larynx where tracheotomy can not be so quickly performed—e. g., in stenosis from a goître, in cicatricial strictures of the larynx, in syphilitic stenosis, etc. In cases of stenosis from goître, for example, it may be of assistance to introduce an œsophageal tube into the larynx.

V. **Tamponing the Trachea.**—To prevent the entrance of blood into the air passages during operations upon the larynx, or in the oral and pharyngeal cavities, one either operates with the head of the patient hanging over the end of the table, after Rose, so that the blood flows out from the mouth and nose, or performs preliminary tracheotomy and tampons the trachea. When operating in the mouth and pharynx one may, after introducing an ordinary tracheal tube, firmly pack the upper aperture of the larynx with aseptic sponges. In complete extirpation of the larynx also, one may introduce the usual tracheal tube, and then, after transverse detachment of the larynx from the trachea, which is accomplished without great hæmorrhage, pack the tracheal stump above the tube with iodoform gauze to prevent the entrance of blood into the lungs.

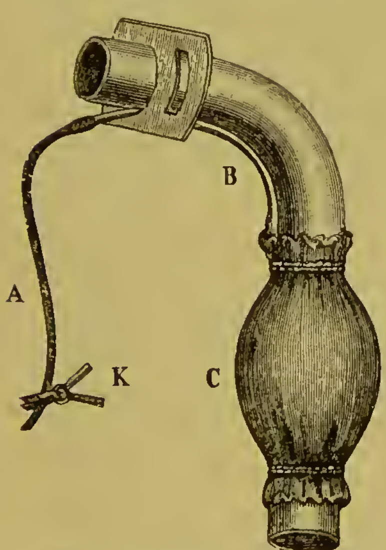


Fig. 328.—Trendelenburg's tampon: *A*, rubber tubing with clamp (*K*); *B*, tube for inflating the rubber bag (*C*).

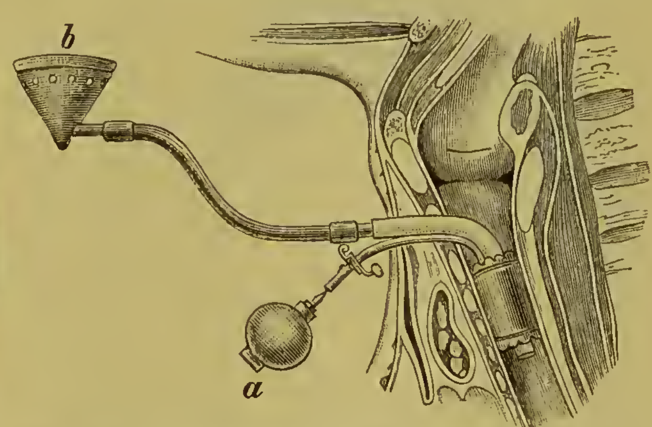


Fig. 329.—Trendelenburg's tampon in position: *a*, bag for inflation of the tampon; *b*, metallic funnel covered with flannel for the anæsthesia.

If one decides to use a tampon, he may select either Trendelenburg's (Figs. 328, 329) or the one devised by Michael and E. Hahn (Fig. 330). The credit of inventing the first useful tampon belongs to Trendelenburg. The tracheal tube (Fig. 328) is provided with a thin India-rubber bag, which is inflated through the India-rubber tubing A and the tube B. The India-rubber tube is then securely closed after the inflation of the bag by tying it firmly with a silk thread. The trachea is completely filled by the inflated India-rubber bag, which fits closely to the tracheal wall. Fig. 329 represents Trendelenburg's tampon when in position in the larynx. If the tampon is to remain in place for some time after the operation, it is better to fill the bag, not with air, but with water or glycerin. Riedel recommends for this tampon a very thick India-rubber material which the instrument-makers Loboschinsky & Co., in Jena, make use of. It can be simply glued to the tube, where otherwise threads encircle it. Michael has constructed a very excellent tampon by fastening a piece of sponge, which has been cut into the proper shape, over an ordinary tracheal tube with several turns of thread and letting it dry. It is a very good plan to fill the sponge with iodoform by dipping it in iodoform ether (1 : 5–7). After removing the thread, the sponge which has dried firmly over the tube is covered with thin rubber tissue. When the tube is to be used as a tampon, a salicylic-acid solution is injected into the sponge with a hypodermic syringe through an opening previously made in the wall of the tube. The sponge then swells and closes the trachea. This tampon can remain for some time after the operation. Finally, the tampon invented by E. Hahn is very serviceable (Fig. 330), which can likewise be made by binding on an aseptic piece of sponge which has been treated with iodoform. The tampon which is used during the operation is afterward replaced by another. It is a very good plan to render the sponge impervious by covering it with gutta-percha paper, after Michael, as otherwise the septic fluids that have been taken up by the sponge can still pass down into the lungs after the operation. Langenbuch has recommended packing the trachea in the following manner after tracheotomy has been performed for diphtheria: A plug of cotton which has lain in a concentrated solution of iodoform and ether is introduced into the trachea, after low tracheotomy, by means of a

Fig. 330.—Tampon after Hahn and Michael.

curved dressing forceps. The threads of the tampon are carried around the neck and tied. The tampon remains four or five days in place, and is then replaced by another or taken away altogether. Low tracheotomy is performed in order that the tampon may not come too near the vocal cords. The results of tracheotomy are thought to have improved since the use of tampons.

VI. **Excision of the Larynx (Laryngectomy).**—Excision of the larynx was first performed by Watson, in Edinburgh, in 1866, for syphilitic stricture. The case ended fatally, in consequence of pneumonia, three weeks after the operation. For the perfection of the operation we are indebted to Billroth and Czerny. Czerny proved by experiments upon dogs (1870) that swallowing is possible after extirpation of the larynx and the epiglottis, and that by inserting a specially constructed T-shaped tube with a metallic tongue, a sort of phonation could be secured. On the ground of these experiments Billroth then, in 1873, successfully performed upon the human subject the first extirpation of the larynx for carcinoma.

Laryngectomy is only indicated in cases of malignant tumours—that is, carcinoma and sarcoma, the latter being much rarer. If the malignant new growth has already broken through the larynx, extirpation is usually contraindicated. The earlier the operation is performed upon these malignant tumours, the greater the possibility of substituting a partial for a complete excision of the larynx. One will be able to confine himself to removal of one half the larynx in case the carcinoma has not yet extended beyond the median line, and the other half of the larynx is wholly intact. E. Hahn begins every laryngeal extirpation with a division of the thyroid cartilage, and then proceeds, according to the condition found, to perform either partial or complete excision. If the epiglottis is still sound, it should not be removed even in complete laryngectomy, although its presence is not especially important in swallowing.

We will take up first the complete extirpation of the larynx.

A few days before this operation is undertaken tracheotomy should be performed in every case. The extirpation is then accomplished with the head of the patient hanging over backward, or in the ordinary position if the trachea is packed (see pages 627 and 628).

The first stages of the operation—i. e., freeing the attachments of the larynx—can be performed with the patient in the ordinary position without packing the larynx. After the latter has been partially freed from its attachments, it is severed transversely from the trachea with as little hæmorrhage as possible, and the stump of the trachea is now packed above the tracheal tube with iodoform gauze.

The incision through the skin follows the median line of the neck from the hyoid bone to a point just below the cricoid cartilage. At the upper end of this longitudinal incision a transverse incision parallel to the greater cornu of the hyoid bone is made on each side between the hyoid bone and the thyroid cartilage.

After dividing the skin and the cervical fascia, the sterno-hyoid muscle is drawn to one side with the edges of the skin and cut through transversely at a suitable point. The freeing of the larynx now begins from the median line by pushing the soft parts to one side, bluntly for the most part, with a periosteal elevator or the handle of a scalpel. The sterno-thyroid and thyro-hyoid muscles are severed with the knife, first on one side and then on the other, as near as possible to their point of insertion on the thyroid cartilage. Meanwhile the inferior laryngeal artery, which arises from the inferior thyroid artery, and the crico-thyroid artery from the superior thyroid, are cut and tied. It is better if these vessels are first ligated in two places and then divided between the ligatures. The lateral lobes of the thyroid gland, which are covered by the sterno-thyroid muscle, are then detached from the thyroid and cricoid cartilages. This is done from above downward by means of a periosteal elevator, and in such a way that the superior thyroid artery (see Fig. 289, page 564) is carefully protected. In order now to detach with the knife the inferior constrictor muscle of the pharynx at its insertion on the thyroid and cricoid cartilages on each side, the soft parts of the edge of the wound are drawn as far as possible to one side with blunt retractors, while the larynx is drawn with a sharp retractor to the opposite side. The detachment of the inferior constrictor muscle of the pharynx must be made close to the cartilage in order that the pharynx may not be opened and the vessels that lie here, the superior laryngeal and the crico-thyroid arteries, and farther outward the superior thyroid artery, may not be injured. The superior laryngeal artery, which arises from the superior thyroid, should be tied in two places before its entrance into the lateral portion of the thyro-hyoid membrane, and then divided.

The remainder of the operation may be performed in different ways. One may either detach the larynx by blunt means from the pharynx on its posterior surface, or this may be done later after the larynx has been separated by a transverse cut from the trachea. Judging from my own experience, the latter course deserves the preference.

In order to divide the trachea transversely below the cricoid cartilage, the former is fixed beforehand by means of a loop of thread. After the transverse detachment of the larynx from the trachea, it is best, as has already been said, to pack the lumen of the tracheal stump

above the tube with iodoform gauze or with small aseptic sponges. The larynx is then drawn forward and upward with a sharp hook, and its posterior surface is now gradually detached from the pharynx from below upward by means of a periosteal elevator and knife. In doing this one comes upon the inferior laryngeal nerve and the inferior laryngeal artery behind the lower cornua of the thyroid cartilage.

The extirpation of the larynx is then finally completed by the transverse division of the thyro-hyoid membrane and the epiglottis. In dividing the thyro-hyoid membrane, the superior laryngeal artery on either side, which has been already tied, may be cut again.

If the epiglottis is to be left, one pierces its base with a sharp-pointed knife and cuts it through on each side, thus severing its connection with the larynx. If, however, the epiglottis is also to be removed, the knife, as in subhyoid pharyngotomy, should be directed obliquely upward and the epiglottic ligaments severed.

The detachment of the larynx, as some have recommended, from above downward, after previous division of the connection between the larynx and the hyoid bone, with the separation of the larynx from the trachea to be undertaken at the end, is, in my opinion, by no means so advisable as the method which has just been described, in which this order is reversed.

The after-treatment of the wound consists in packing it with iodoform gauze; suturing should be discarded. The two transverse incisions only at the upper end of the wound may be partially closed by a few stitches. If it has proved necessary to remove parts of the pharynx also, the wound in the pharynx should likewise be sutured. The stump of the trachea is fastened into the wound by means of catgut or silk. The chief indications are to keep the wound aseptic by packing it with iodoform gauze, and to avoid aspiration pneumonia and burrowing of pus. By packing the wound with iodoform gauze the secretions of the mouth and throat are kept from the wound, and it is also possible to allow the patient to swallow. For a few days nourishment is given through a stomach tube. To prevent burrowing of pus in the direction of the thoracic cavity the head of the patient should be kept as low as possible. Aspiration pneumonia is prevented by packing the stump of the trachea above the tube.

Of late the pharynx has been shut off from the wound by means of rows of sutures, either temporarily until an artificial larynx has been inserted, or permanently if one does not make use of the latter. The advantages of this method as regards the prevention of complications on the part of the lungs, the healing of the wound, the feeding of the patient, etc., are self-evident.

About the end of the second or during the third week one inserts in the granulating wound, as compensation for the lost organ of speech, a so-called artificial larynx—after Gussenbauer, P. Bruns, or J. Wolff. The artificial larynx which was invented by Gussenbauer (Fig. 331) consists of a tracheal or breathing tube, which is first introduced, and a speaking tube which is pushed into the first in an upward direction. The artificial larynx has been recently improved, especially by P. Bruns and J. Wolff. Wolff's apparatus secured in one case loud speech which had a natural sound and which could be maintained for hours. Many patients prefer a simple tracheal or T-tube. They can then usually only make themselves understood in a lisping voice. As has been shown, however, by an observation made by Ziegel and H. Schmid, early and methodical exercises may enable a patient with complete absence of the larynx to speak aloud and intelligibly without an artificial larynx. According to Landois and Strübing, who collected from the literature of the subject ten analogous cases—e. g., of Renaud, Bose, Roux, Balassa, Störck, Bandler, and others—the possibility of speech after complete extirpation of the larynx is due to the fact that air can collect in sufficient quantity in the pharyngeal cavity. The air is forced forward from here into the mouth by the contraction of the surrounding soft parts, and by breaking through a barrier made by the person himself, or by friction of the air against a constricted part of the oral cavity, or by vibrations of the parts that cause the constriction, the consonants are produced. As the larynx which produces the tones is wanting, the vowels can only be formed in connection with the consonants by means of the vibrations of air in the oral cavity produced in forming the consonants. The sound of the letter *h* which is produced in the larynx can not usually be given. By approximating the dorsum of the tongue to the posterior pharyngeal wall and causing a narrowing at this point, vowels also may be formed without the aid of the consonants, and under certain circumstances a peculiar *h* sound also. The larger the air space, the greater the possibility of continued speech. In the case observed by Solis-Cohen, speech was made possible by the presence of a band of tissue, which the patient used in place of the absent vocal cords.

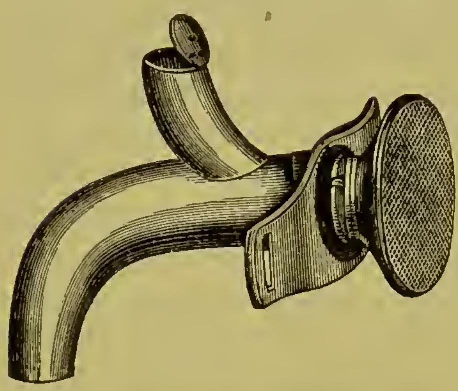


Fig. 331.—Gussenbauer's artificial larynx.

Perier recommends performing laryngectomy without preliminary tracheotomy. An ⊥-shaped incision is made from the hyoid bone to a point below the cricoid cartilage. After freeing the larynx laterally, two stout threads are passed through the side of the trachea at the place where it is to be divided. The trachea is then divided upon a grooved director, a special form of tube inserted into the bronchial end of the trachea with an arrangement for continuing the narcosis, and the larynx is then extirpated.

The technique of unilateral extirpation of the larynx follows from the above-given description of its complete extirpation. After divid-

ing the thyroid cartilage to one side of the median line, with preservation of the insertion of the sound vocal cord, and after severing the cricoid cartilage, the diseased half is extirpated in conformity with the rules given above. Unilateral laryngectomy is decidedly less dangerous than the complete removal, and patients can make themselves understood without an artificial larynx. They can speak, as, for example, in a case of Schede's, with a loud though somewhat husky voice, as a rigid cicatrix that projects horizontally upon the side that has been operated upon sometimes assumes, as it were, the function of the extirpated vocal cord.

The technique of other atypical resections of the larynx with or without preservation of the perichondrium and the mucous membrane —e. g., the resection of the cricoid or thyroid cartilage for chondritic processes or strictures—also follows from what has already been said. Some surgeons have suggested the preservation of the cricoid cartilage, if possible, in connection with unilateral or complete extirpation of the larynx, in case it is sound. According to E. Hahn, this is not advisable, because the cricoid cartilage can easily cause difficulty in swallowing.

E. Hahn collected (1885) seventy-six cases of complete extirpation of the larynx. Of these patients, thirty-two, or 42·1 per cent, died in consequence of the operation—twenty-six of them in the first fortnight and six in from three to six weeks. They died chiefly from pneumonia and bronchitis. Of the thirty-five who recovered after being operated upon for carcinoma, twenty died from recurrence of the disease in the first nine months, and of the remaining fifteen only seven, at the time when Hahn completed his tabulation, could be regarded as radically cured. One had been four years, and six from fourteen to nineteen months, without recurrence. In the cases last mentioned recurrence may have occurred, as E. Hahn observed a regionary recurrence in one case seventeen months after the operation.

According to statistics published by Hahn in 1887, only two out of fifteen patients operated upon for carcinoma of the larynx were cured, one having lived without recurrence seven years, and one a year and a half after the operation. The cause of the unfavourable results attending extirpation of the larynx for carcinoma is due, above all, to the fact that most patients consult a surgeon too late. Only those cases in which there has been no recurrence for three years can be looked upon as cured.

Scheier, Krajewski, Wroblewski, and Tauber have recently given valuable statistical information concerning extirpation of the larynx, from which it is made clear that permanent cures, especially after complete extirpation for carcinoma, are very rare, and that the mortality attending the operation itself is comparatively high—that is, that complete excision of the larynx as such is a very serious, life-endangering operation. S. Tauber collected from literature one hundred and sixty-three cases of laryngectomy performed for various diseases. The operation terminated fatally in 69·9 per cent. of these cases. Especially after complete laryngectomy and much less frequently

after partial laryngectomy death sometimes takes place on the second day, more often on the fourth to fifth, with marked increase or diminution in the pulse rate in consequence of irritation of the superior laryngeal nerves, with involvement, it may be, of the pneumogastrics.

The great mortality and the poor guarantee of non-recurrence have so lowered the value of complete laryngectomy in the eyes of surgeons that it is now still less frequently performed. It is only to be resorted to in cases where there is still something to hope for from the operation. Of one hundred and seventy-six patients upon whom the operation was performed for carcinoma, only eight, according to Wassermann, were permanently cured (see also page 609).

Complete extirpation of the larynx has been performed six times for sarcoma. All these patients recovered. Two have been two years without recurrence, two died from recurrence of the disease, one from tuberculosis of the lungs, and one was operated upon but a short time ago.

The mortality attending partial (unilateral) extirpation of the larynx is much smaller than that following its complete removal. Of fifteen cases, but two, or 13·7 per cent, according to E. Hahn, terminated fatally in the first fortnight in consequence of the operation. Of the seven patients operated upon for carcinoma, three were still free from recurrence of the disease after from eleven to nineteen months. The functional results also are much better after partial than after complete extirpation, and it is therefore desirable in every case to resort to operation as early as possible.

Defects in the trachea may be closed by skin flaps or osteoplastic flaps taken from the clavicle or the sternum.

CHAPTER XII.

INJURIES AND DISEASES OF THE ŒSOPHAGUS.

For injuries, see § 93, page 535.—Examination of the œsophagus.—Introduction of œsophageal bougies.—Congenital malformations.—Foreign bodies.—Inflammatory processes (see also § 93, page 535, and § 94, page 538).—Varicosities.—Strictures.—Dilatations and diverticula.—Tumours.—Operations on the œsophagus: Internal and external œsophagotomy.—Formation of an œsophageal fistula (œsophagostomy).—Resection of the œsophagus.

§ 107. **Examination of the Œsophagus.**—Inspection and auscultation are of slight value in making an examination of the œsophagus. Only the pharynx can be inspected with the aid of a mirror (see Pharyngo-rhinoscopy, page 266, and Laryngoscopy, page 592). Trouvé, Mikulicz, Nitze, and Leiter have constructed œsophagoscopes and gastroscopes for direct inspection of the œsophagus and the stomach, but these instruments are as yet of little service.

Auscultation of the œsophagus was especially recommended by Hamburger. A stethoscope is placed alongside the trachea on the left side from the hyoid bone to the supraclavicular fossa so as to listen to the sounds caused by the passage of fluids or semisolid and solid food through the œsophagus. The diagnostic significance of this auscultation is very small. The abnormal character of the sounds is perhaps most distinctly recognised in strictures.

Percussion may be of value under certain circumstances in case of a tumour, periœsophageal abscess, or diverticulum filled with gas or food.

Palpation of the œsophagus is either done from without by seizing between the fingers the soft parts that lie between the trachea and the spinal column, or from within the mouth by introducing the forefinger into the lower part of the pharynx and upper part of the œsophagus.

The most important method of examination of the entire œsophagus in cases, for example, of foreign bodies, strictures, diverticula, etc., is the use of a hollow stomach tube or a solid œsophageal bougie. Stomach tubes are also introduced for feeding patients—e. g., after operations in the mouth or in the œsophagus, or in insane persons, etc.

In the latter cases and in lockjaw the tube has sometimes to be introduced through the nose.

Œsophageal tubes and bougies are usually flexible and are made of India rubber. There are also bougies made of thin, elastic whalebone with a conical, olive-shaped, or spherical head of ivory or horn, of varying size, which, like all bougies, are used especially for the dilatation of strictures.

The introduction of an œsophageal bougie or a stomach tube is accomplished as follows: One grasps it like a penholder near its lower end after smearing it with oil or vaseline. The patient sits upon a chair, opens the mouth as widely as possible, and inclines the head somewhat backward. The tongue of the patient is depressed lightly with the left forefinger, and the bougie or tube is then pushed down into the œsophagus along the posterior pharyngeal wall. Swallowing movements usually aid its entrance, and if there is no obstacle it easily glides down into the stomach. In case of stricture or a foreign body in the œsophagus, one must proceed with great caution in order to avoid injury or perforation of the organ. In consequence of the latter, death may ensue from a septic phlegmon or from puncture of the aorta with a sharp foreign body, accompanied by internal hæmorrhage. In case also of extreme scoliosis of the vertebral column, the introduction of stiff bougies may meet with insuperable obstacles (Hacker).

In case of anæsthesia of the pharynx and the larynx, the bougie or tube may easily enter the larynx instead of the œsophagus.

§ 108. **Congenital Malformations of the Œsophagus.**—In order to understand correctly the congenital malformations of the œsophagus in so far as their origin is concerned, the following brief review of the development of the œsophagus should be given:

The entire digestive canal from the mouth to the anus is formed, as is well known, from three parts—the foregut, the midgut, and the hindgut. The pharynx and œsophagus develop from the foregut. The primitive buccal cavity grows toward the foregut in the form of an involution of the epiblast. The thin membrane separating the two finally disappears and as residue of the same there remain the palatine arches and the uvula at the point of junction of the buccal cavity and the foregut. Up to a certain period in the fœtal development, the pharynx and the œsophagus are connected with the respiratory apparatus. In the rabbit, according to A. Kölliker, the foregut divides on about the tenth day into two parts—an anterior (ventral) for the lungs and the trachea, and a posterior (dorsal) for the pharynx and œsophagus. The trachea and œsophagus remain undivided in the pharynx. In man, the trachea and œsophagus become separated from each other at the beginning of the second month.

This brief description of the development of the œsophagus explains the abnormal communication between the trachea and the œsophagus which occasionally occurs. Such a fœtus is, of course, unable to live. Death occurs soon after birth, although, according to

König, cases have been observed in which the child has lived from three to seven or even nine days. It is usually found that the upper part of the œsophagus is dilated in the form of a *cul-de-sac* and is closed, while the lower part opens into the bronchio-tracheal space, usually near the bifurcation of the trachea, less frequently into a bronchus. In the mildest cases the œsophagus is normally formed, and there is a fistula between it and the trachea.

Of other congenital abnormalities there are also to be mentioned the very rare congenital strictures and the congenital diverticula of the œsophagus, concerning whose occurrence there is as yet, according to König, little reliable information. Regarding acquired strictures and diverticula, see § 111, page 643, and § 112, page 649.

§ 109. **Foreign Bodies in the Œsophagus.**—The foreign bodies that enter the œsophagus are very varied, especially among children and insane persons. They consist very often of portions of food, imperfectly masticated pieces of meat, pieces of bone, fish bones, or fruit stones; also, among children and the insane, of pebbles, coins, buttons, needles, etc. During sleep, or while under the influence of an anæsthetic, artificial teeth may be swallowed and become wedged in the œsophagus. Spoons, forks, and knives even have been found in the œsophagus of jugglers and insane individuals. Nematodes may gain access to the œsophagus from the stomach. As is mentioned by König, live fishes have in some cases entered the œsophagus and have caused death by pressure upon the entrance to the larynx. The most frequent foreign bodies are bones and false teeth, composing, according to Egloff, sixty-two per cent of one hundred and thirty-five cases.

The foreign bodies that pass in from the mouth remain lodged either in the pharynx or at the entrance to the œsophagus, and too large morsels of meat, for instance, may here cause death by pressure upon the superior aperture of the larynx, as in the case mentioned on page 610, for example, which came under my own observation.

Foreign bodies are lodged in the œsophagus itself at those places especially where it is normally constricted—that is, (1) in the region of the third dorsal vertebra where the œsophagus crosses to the left side of the trachea, (2) where it passes through the diaphragm and (3) at the cardiac orifice.

The symptoms caused by a foreign body in the œsophagus vary according to the size of the body and its character in other respects. Bodies may remain wedged in the œsophagus for different periods of time. The shape and size of the body, as well as the duration of its stay, are of great significance in their bearing upon the final result, as is also shown by the statistics of G. Fischer, who collected from

literature eighty cases in which foreign bodies had become impacted in the œsophagus. Generally speaking, there are symptoms of stenosis of the œsophagus and sometimes of the trachea also, as well as pain on attempting to swallow.

The œsophagus may be so obstructed by the presence of large, foreign bodies—large morsels of meat, for instance, that have become wedged in—that all the food remains above the body and is finally regurgitated. Smaller bodies also, such as bits of bone, fish bones, or needles, can cause great trouble when they become firmly wedged in crosswise.

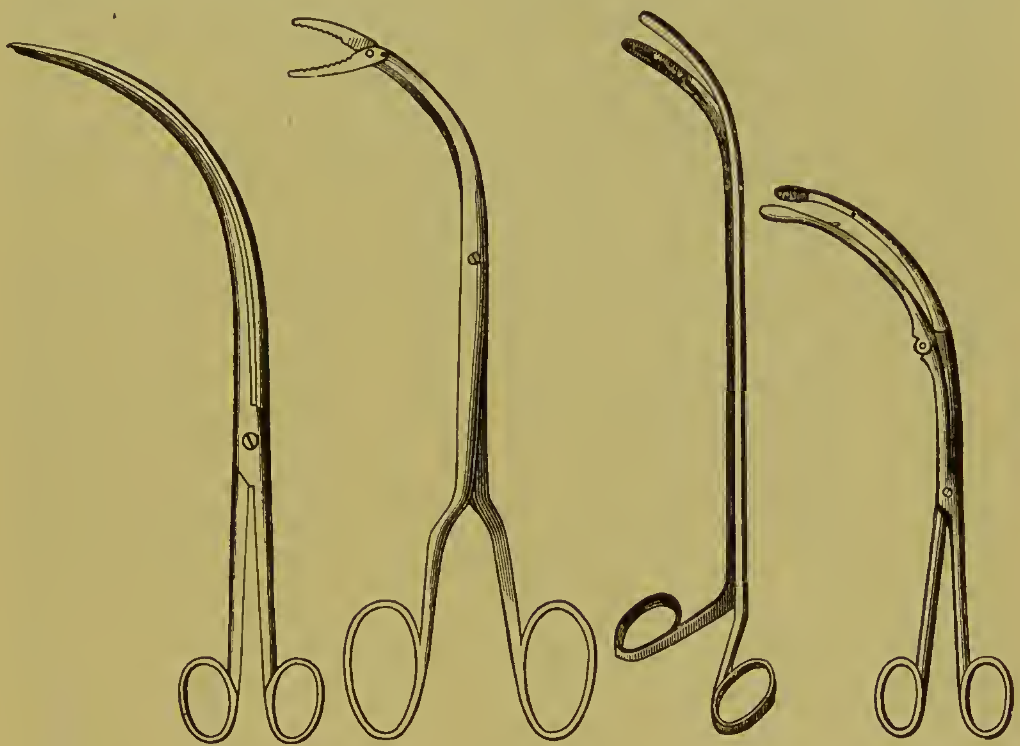
The further course and the outcome of the entrance of foreign bodies into the œsophagus consist usually in recovery after spontaneous or artificial removal of the body.

According to König, about half of all the foreign bodies that enter the œsophagus are regurgitated spontaneously through the mouth or pass down into the stomach and are discharged *per rectum* without doing any injury. Large or pointed bodies may give rise to various disturbances after entering the stomach or the intestines, particularly disturbances of digestion, obstruction to the passage of the contents of the stomach and intestines, and perforation of these organs. The foreign body may lead in the latter case to death from general peritonitis, or the hole caused by the perforation may heal over and the body come out through the skin, without any bad results, in an entirely different part of the body (see § 166, Foreign Bodies in the Stomach and Intestines). Needles that have been swallowed are particularly likely to wander about in this way. Years go by sometimes before the body that has been swallowed appears. Foreign bodies that have been impacted in the œsophagus may also be discharged through an abscess, either at the place where they were located, or, after moving about, at some remote part of the body.

The unfavourable consequences of the presence of foreign bodies in the œsophagus are compression of the air passages and especially perforation of the œsophagus, with subsequent septic phlegmon of the mediastinum. Of the neighbouring organs, the ones most likely to be injured are the larynx, the trachea, the bronchi, the lungs, and the pleura. Death results most commonly from compression of the air passages—particularly the superior aperture of the larynx—by large, foreign bodies, or from septic mediastinitis, empyema, and pneumonia in consequence of the passage of septic material into the mediastinum, the pleural cavity, and the lung, after perforation of the œsophagus. In rare cases injuries to the heart occur from pointed bodies that have become impacted; less frequently, injuries to the aorta and other ves-

sels—e. g., the common carotid, ascending cervical, inferior thyroid, pulmonary and subclavian arteries, and the superior vena cava. The vessels are sometimes eroded only after the lapse of a considerable period in consequence of a periœsophageal abscess, and this explains why death occurs sometimes quite suddenly from internal hæmorrhage a long time afterward, when the foreign body has been forgotten.

The diagnosis of a foreign body in the œsophagus is usually easily made from the statements of the patient and from the symptoms. All foreign bodies that are located in the pharynx or at the entrance to the œsophagus can be either seen by depressing the tongue, for instance, or by laryngoscopy,



a *b* *c* *d*

Fig. 332.—Pharyngeal forceps: *a*, forceps for seizing a body from in front and behind; *b*, Charrière's forceps; *c*, American pharyngeal forceps; *d*, forceps with articulated blades.

or felt by introducing the right forefinger. For the diagnosis of bodies that are more deeply situated, the insertion of an ordinary œsophageal bougie or a whalebone probe is especially to be recommended. The detection of the presence of small bodies such as needles is the most difficult. One should also always palpate the œsophagus from without, in the manner described above, page 635. The location of the body is sometimes indicated by pain felt in a particular spot, but one is very often deceived in this. To determine the degree of the stenosis caused by a body that has become impacted in the œsophagus, the patient is made to swallow liquids.

The treatment of foreign bodies in the œsophagus is easiest when they can be seen or felt at its entrance. They can then be removed

usually without difficulty by means of curved pharyngeal forceps (Fig. 332). The extraction may be facilitated by drawing the larynx and hyoid bone well forward, after Trendelenburg. If the head is bent as far back as possible, straight forceps can be used for the extraction of bodies that are located in the pharynx and near the entrance to the œsophagus. By pressing and kneading one can sometimes start bodies that can be felt, and push them upward so that they are discharged through the mouth again by regurgitation.

Fig. 333. — Gräfe's coin-catcher.

If the body can not be extracted and there is danger in delay, subhyoid pharyngotomy is indicated, in case it is located in the lower part of the pharynx or the upper part of the œsophagus. In this operation (see page 440) the lower part of the pharynx is opened by a transverse incision through the thyro-hyoid membrane between the hyoid bone and the thyroid cartilage.

In case of bodies which have a deeper location their extraction through the mouth should likewise always be tried first. For the removal of bodies thus located numerous instruments have been recommended varying according to the nature of the body in question. Long, angular œsophageal forceps are very useful—Mathieu's jointed forceps, for instance. For the extraction of coins Gräfe's coin-catcher is useful (Fig. 333) or Collins's œsophageal hook. For removing needles, fish bones, etc., a whalebone bougie provided with a sponge, or Weiss's brush, may be used. The latter instrument, Weiss's brush or fish-bone catcher (Fig. 334), consists of a flexible tube with a rod which projects at each end of the tube and carries a sponge at its lower end. By pulling the rod, hog's bristles open out at the lower end so as to form a compact disk (Fig. 334 *b*). All the instruments that have been mentioned are carried beyond the foreign body and then drawn back with it. In the case of sensitive persons with spasm of the muscles, an anæsthetic is sometimes necessary. Under certain circumstances it is a good plan to extract the body with the head of the patient hanging over backward.

Fig. 334.—Weiss's fish-bone catcher: *a*, with the bristles closed; *b*, with the bristles in position.

If extraction through the mouth is not successful, one may push suitable (not too pointed) bodies down into the stomach and allow them to pass off

per rectum. With Collins's œsophageal hook it is possible to let go of the body in case it can not be extracted. This pushing of bodies down into the stomach is best accomplished by means of a whalebone rod whose end is provided with a sponge or an ivory or metallic head. Much care is to be exercised in doing this. Very pointed bodies must never be treated in this way, as the above-mentioned dangerous injuries to the œsophagus, the large vessels, etc., may easily ensue.

If repeated attempts at extraction are fruitless and dangers are likely to arise from the retention of the body in the œsophagus—e. g., secondary injuries, hæmorrhages, or obstruction to the passage of food or to respiration—the attempt should be made to remove any body that is located high up as soon as possible by opening the œsophagus from the outside; that is, by external œsophagotomy. Of thirty-two patients thus treated, twenty-six, according to König, were cured. G. Fischer collected one hundred and eight cases in which œsophagotomy was performed for the removal of foreign bodies. The mortality amounted to twenty-six per cent. Egloff's statistics (one hundred and thirty-five cases) give a mortality of 24·8 per cent. The operation in itself, if performed under aseptic methods, has no special danger; but, unfortunately, it is often undertaken too late after complicating injuries and inflammations have already been caused by the foreign body. For the technique of œsophagotomy the reader is referred to pages 655, 656. One may also remove bodies that have become lodged in the lower part of the œsophagus by opening the stomach (Bull, Richardson).

For periœsophageal phlegmons and abscesses exposure, if possible, of the damaged part of the œsophagus with subsequent drainage is indicated. In case of secondary empyema, thoracotomy is necessary; and in case of foreign bodies in the stomach, opening the stomach or intestine by gastrotomy or enterotomy may be imperative (see §§ 165, 169, Operations on the Stomach and Intestines).

§ 110. **Inflammations of the Œsophagus.**—Acute and chronic catarrhal inflammations of the œsophagus are not infrequent, but, as a rule, they have no special interest for the surgeon. They are observed most frequently from traumatism, from swallowing irritating or too hot food, and in drunkards. Thickening of the mucous membrane and relaxation of the œsophagus with a tendency to diffuse dilatation sometimes follow such chronic catarrhal inflammations (Zenker and Ziemssen). Strictures of the œsophagus can not arise from simple increase in the thickness of its walls. In rare cases catarrhal inflammations of the œsophagus have been observed which, as in the vagina and urethra, lead to the formation of pseudo-croupous membranes or firm thick layers of epithelium which close the lumen and thereby produce rather acutely developing

strictures of the œsophagus (pseudo-croupous œsophagitis [Birch-Hirschfeld], exfoliative œsophagitis [Reichman]).

From the extension of diphtheria and croup, analogous diseases of the œsophagus sometimes occur. Diphtheria of the œsophagus may spread as far as the stomach. Diphtheria of the stomach is sometimes found following diphtheria of the throat, while the œsophagus is not diseased at all. Diphtheritic disease of the œsophagus also occurs sometimes in the course of severe infectious diseases (typhoid fever, measles, scarlet fever, small-pox, pyæmia, cholera, etc.).

The severe cases of thrush in the œsophagus must not be confounded with œsophageal diphtheria. Continuous layers may here be formed also, so that complete casts of the œsophagus are coughed out.

Phlegmonous inflammation of the œsophagus (œsophagitis phlegmonosa) occurs especially after injuries or from the presence of foreign bodies, or is secondary to phlegmonous inflammation of the adjacent parts and of the pharynx and the stomach. Among drunkards rupture of the œsophagus takes place in exceptional cases from slight traumatisms with subsequent phlegmonous periœsophagitis, if immediate death does not ensue from hæmorrhage with severe hæmatemesis (Morley). Phlegmonous œsophagitis is either a circumscribed or more diffuse suppurative infiltration of the submucous connective tissue and in its worst forms of the muscular layer also, so that the mucous membrane is lifted from the subjacent parts and frequently perforated in different places like a sieve. From the entrance of particles of food into the submucous pus focus, large septic abscesses or spreading suppurative processes result. If the mucous membrane continues to remain lifted up and perforated, corresponding submucous cavities covered with epithelium may gradually develop—diverticula, as it were, of the œsophagus. These submucous abscesses or cavities, with fistulous communication with the œsophagus, originate sometimes within the latter and sometimes *vice versa*—e. g., when a spinal abscess perforates the œsophagus.

Analogous phlegmonous inflammations also result from swallowing caustic fluids—e. g., sulphuric, hydrochloric, or nitric acid, caustic potash or caustic soda. The *œsophagitis toxica seu corrosiva* thus produced is characterized by eschar formation in the œsophagus varying in degree. In the mildest forms there is merely a desquamation of epithelium, with subsequent return to the normal condition. In other and severer cases deeper eschars occur in the mucous membrane and sometimes also in the submucous and even the muscular layers. Discoloured, gangrenous masses are thus formed which are in part cast off externally and in part enter the stomach. Death follows from second-

ary, septic, periœsophageal suppuration and burrowing of pus. If the patient recovers, corresponding strictures ensue from such eschar formation (see page 644), whose degree and extent depend upon those of the injury to the œsophagus.

Fig. 335.—Varicose veins of the œsophagus (Kast and Rumpel).

Tubercular and syphilitic diseases of the œsophagus are very rare, and are analogous to the corresponding affections of the mouth and pharynx (see these). Strictures may arise from cicatrization of syphilitic and tubercular processes.

The occurrence of the so-called round œsophageal ulcer, which is thought to be analogous to the round ulcer of the stomach, is doubted by Zenker and Ziemssen, but has been observed by Quincke, Chiari, Kehrer, and others. This ulcer in the lower part of the œsophagus originates in the same way, probably, as the round gastric ulcer, from necrosis of tissue in consequence of the digestive action of the gastric juice.

Acquired fistulæ between the œsophagus and the trachea occur especially from injuries and ulcerations (carcinomatous). If one introduces a hollow œsophageal bougie in such cases down to the fistula, a continuous current of air sometimes escapes from the bougie, which shows itself by the formation of air bubbles when one places an India-rubber tube which is fastened to the bougie under water. Single air bubbles occasionally escape also from a hollow bougie inserted into the œsophagus of healthy persons (Gerhardt). Varicose veins of the œsophagus (see Fig. 335) should also be briefly mentioned here, which sometimes occur among older people and may occasion profuse hæmorrhages (see page 536).

§ 111. **Strictures of the Œsophagus.**—Strictures of the œsophagus are of the greatest importance for the surgeon. König makes the following very practical classification of strictures with reference to their origin ;

1. Obstructions to the passage of food located within the œsophagus —viz., inflammatory, spasmodic, or cicatricial strictures, foreign bodies, tumours, and diverticula.

2. Obstructions to the passage of food located outside the œsophagus, especially tumours of the thyroid gland, the tracheal glands, and the mediastinum, aneurisms, etc.

One may, with Zenker and Ziemssen, distinguish five principal forms of stricture, with reference to their origin : 1, Congenital stric-

tures; 2, compression strictures; 3, obturation strictures; 4, cicatricial strictures; 5, spasmodic strictures.

The most frequent and the most extensive strictures are those from cicatricial contraction following the action of caustics—such, for example, as sulphuric acid, hydrochloric acid, caustic potash, etc. After deep destruction by caustics the œsophagus is transformed into very thick cicatricial tissue, so that it sometimes admits only a fine probe. The extent of cicatricial strictures in the transverse and longitudinal diameter of the œsophagus is very variable. Many of them are annular—that is, they include the entire periphery of the organ, whereas others take in but a part of it. Hacker, who examined post mortem a large number of strictures following cauterization, found that the stenoses of the œsophagus from this cause are situated mainly at those points where the normal organ has a somewhat narrowed lumen or is pressed upon by adjacent organs. The normal constrictions of the œsophagus are (1) at the level of the cricoid cartilage, (2) opposite the bifurcation of the trachea, and (3) just above the cardiac orifice. The most marked strictures from cauterization of the œsophagus are found, according to Hacker, at and above the lowest of these constrictions.

The membranous valvular strictures are usually of congenital origin.

Compression strictures are caused especially by tumours of the thyroid gland and of the lymph glands of the neck and the mediastinum, and also by aneurisms of the aorta. Functional disturbances only occur when the œsophagus is compressed on all sides.

Obturation strictures are due to foreign bodies which have entered the œsophagus and also to tumours, carcinomata most frequently, and sometimes polypous growths.

Syphilitic strictures are very rare, as syphilitic processes in the œsophagus are exceptional.

Spasmodic strictures—that is, local contractions of the circular fibres of the œsophagus—are observed especially in connection with disturbances of the nervous system: hysteria, for instance. This spasm of the œsophagus occurs particularly during attempts to swallow, and may reach such a degree in nervous persons that even fluids can no longer be swallowed, because at every attempt the œsophagus closes convulsively (Eloy).

The chief symptom of stricture of the œsophagus is dysphagia—that is, more or less difficulty in the passage of the food through the œsophagus into the stomach. In cases of extreme constriction the passage of solids and even of fluids may be altogether prevented. Solid food especially remains above the point of constriction, and is either

gradually worked down into the stomach or regurgitated after a time, according to the degree of the stricture. On account of the accumulation of food, the œsophagus is usually dilated above the stricture. The dysphagia increases very gradually, as a rule, and when the stricture has become more or less completely impervious to the passage of solids and fluids, the emaciation of the patient is very rapid, and if the stricture is not remedied or the nourishment of the patient through the stomach provided for by the formation of a gastric fistula (gastrostomy), death may follow within a few months, simply from inanition. Death frequently results from the underlying cause of the stricture—e. g., carcinoma, or from perforation of the œsophagus, with subsequent periœsophageal suppuration, which not infrequently follows a careless use of œsophageal bougies. The outcome of a stricture of the œsophagus depends in the main upon the possibility of overcoming it by operation, particularly from the outside. Cicatricial strictures very frequently recur after their dilatation, and one must often content himself with meagre success in their treatment. I have, however, also seen strikingly good and permanent results.

The diagnosis of a stricture of the œsophagus is best made by the introduction of an œsophageal bougie as described on page 635. Bougies should be passed very cautiously, so that accessory injuries or even perforation of the organ, with subsequent fatal septic phlegmon, may be avoided. In many cases external palpation of the œsophagus and auscultation are to be recommended (see page 635). For strictures that are situated high up, the examination of the pharynx and the entrance to the œsophagus by means of the laryngoscope and by palpation with the finger are of service.

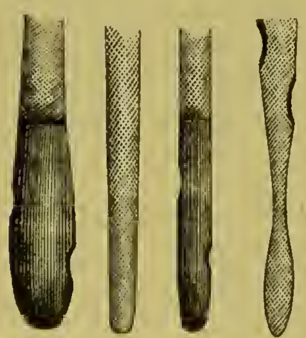
It is especially important to determine the location and the degree of the stricture by the careful introduction of elastic œsophageal bougies of the proper size. The location may be approximately determined by measuring the distance of the end of the bougie from the teeth. Its approximate length can also be estimated by means of a bougie with an olive-shaped end. When the olive reaches the upper end of the stricture a mark is made upon the bougie in front of the teeth. After the olive has passed through the stricture it is drawn back to the lower end of the constriction and another mark is then made upon the bougie in front of the teeth. The distance between the two marks gives the length of the stricture and the length of the olive. By subtracting the latter, one obtains approximately the length of the stricture.

It is also of great importance to determine the character of the stricture, whether, for example, it is carcinomatous or not. In case of carcinoma, cancer cells are sometimes found in the vomited matter and in the eye of the stomach tube. The history of the case usually gives valuable information as to the character of the stricture—viz., whether a traumatism has occurred, and whether a foreign body has been swallowed, or the stricture has developed spontaneously. The age of the patient is also to be considered. Carcinoma,

for instance, is usually found only after the fortieth year. In case of a stricture from compression there should be a careful examination made with reference to the presence of a tumour, aneurism, retrovisceral abscess, etc. In this form of stricture the dysphagia may be very great, and at the same time a large-sized bougie may be introduced with ease into the stomach. Compression strictures of the œsophagus may also arise from thickening of the cricoid cartilage. If, in such cases, the larynx is drawn forward from the spinal column, the supposed constriction immediately disappears.

The treatment of strictures of the œsophagus demands, first of all, that the cause of the existing dysphagia be determined. The treatment of the stricture, as such, consists either in its gradual dilatation by means of bougies or in an operation from the outside or inside—that is, external or internal œsophagotomy; or, finally, in case of impermeable stricture, in gastrostomy or the formation of a gastric fistula. In suitable cases operative treatment should be combined with gradual dilatation with bougies. In fresh burns from caustics I recommend early gastrostomy as soon as the patient experiences difficulty in swallowing fluids. The inflammatory swelling of the œsophagus quickly subsides after gastrostomy, and further infection is prevented. One should not lose too much time with nutritive enemata. In some cases it is only by a combination of gastrostomy and œsophagotomy that one can cure the stricture.

The gradual dilatation of strictures is accomplished by introducing elastic œsophageal bougies or tubes of proper diameter. The end of these instruments has different shapes, and a corresponding distinction is made between cylindrical, conical, olive-shaped, and probe-pointed bougies (Fig. 336). The conical elastic bougies and those made of whalebone with an ivory olive-shaped point (Fig. 337 *a*), or with otherwise formed end-pieces of variable diameter and length, are the most useful for strictures. Trousseau's bougie (Fig. 337 *b*), which is very good, has at each end three ivory olives of different sizes. Metallic bougies — block-tin bougies, for instance—I never use. I also question the wisdom of introducing compressed sponge or laminaria—that is, substances which swell within the stricture and thus dilate it. Le Fort and others recommend elastic urethral bougies loaded with lead, which are provided at their base with a metallic ring, and a whalebone rod which is firmly screwed on and which serves to lengthen the bougie. The complicated dilators which have been recommended have, in my opinion, no



a *b* *c* *d*

FIG. 336.—Œsophageal bougies: *a*, olive shaped; *b*, conical; *c*, cyclindrical; *d*, probe-pointed.

advantages over an elastic bougie, which is always the best instrument for the purpose. The dilator recently invented by Schreiber consists of a hollow bougie, and on the end that is to be dilated is a rubber cap, whose size is regulated by hydraulic pressure from the other end.

The cylindrical bougies recommended by Billroth, which are made of cloth and filled with mercury, seem to me very practical. They work under higher pressure, owing to their greater weight, and, as it were, force an entrance into the stricture.

The bougies are introduced in the manner described on page 635. In the first examination of a stricture of the œsophagus it is best to begin with the introduction of large sizes, and then to try smaller sizes until one is found, if possible, which will pass through the stricture. If the stricture is very narrow and rigid, and is situated high up, one may make use of a small elastic urethral catheter or urethral bougie. From the smaller sizes one proceeds gradually to larger and larger ones. The bougies are passed daily and are allowed to remain in place from ten or fifteen minutes to half an hour. If an œsophageal tube can be introduced into the stomach, the nourishment of the patient is usually undertaken at once by pouring in milk, bouillon with egg, and finely chopped meat, wine, etc. If one desires to let the tube or bougie stay in place for some time—several hours or a day, for instance—it is more comfortable for the patient to have it introduced through the nose. Senator speaks well of the use of laminaria bougies that swell.

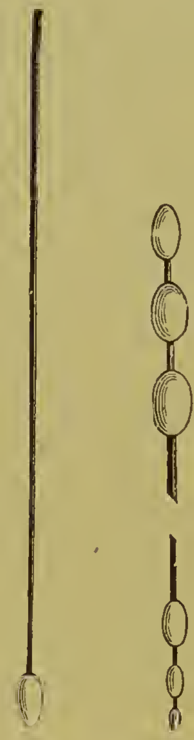


FIG. 337.—*a*, œsophageal bougie with ivory tip; *b*, Trousseau's bougie with three ivory olive tips of different sizes on each end.

Strictures of the œsophagus have been recently treated in Leyden's clinic by the introduction of permanent tubes, and with marked success (Renvers, Waetzoldt). This method consists in inserting with instruments adapted to the purpose tubes of hard India rubber of proper length (usually rather short) into the constricted part, and especially in case of carcinomatous strictures, letting them lie there for weeks and months. The patient is fed through these tubes, which can be easily removed if a silk thread is fastened to them before their insertion. The passage of bougies must be repeated from time to time, especially in cicatricial strictures, as they frequently recur.

If the attempt to render a stricture pervious by gradual dilatation is not successful, there remains either division of the stricture by inter-

nal or external œsophagotomy or the formation of a gastric fistula (gastrostomy). If the stricture is situated high up in the region of the pharynx and the beginning of the œsophagus, one may make an œsophageal fistula (œsophagostomy) for the sake of feeding the patient through an œsophageal tube.

Internal œsophagotomy—that is, division of the stricture from the inside—which is not without risk, comes into consideration when the constriction is low down and not very extensive, while external œsophagotomy is to be performed, if possible, in case the stricture is situated in the cervical portion of the œsophagus, and it may be combined in case of carcinoma, for instance, with resection of the diseased portion of the œsophagus. It has been proved by Menzel and Czerny, from experiments upon dogs, that after resection of a portion of the œsophagus, healing is possible without appreciable stricture. One may also, according to Gussenbauer, combine, in suitable cases, external and internal œsophagotomy—that is, one opens the cervical portion of the œsophagus from the outside, divides the stricture from the inside or dilates it by means of forceps, and then, after division or forced dilatation, introduces an œsophageal tube for a time, preferably through the nose. Heineke and Graser recommend that in deep strictnres external œsophagotomy be promptly performed, and the stricture then dilated by introducing bougies through the wound and allowing them to remain in place for some time. In fact, a permanently favourable result is often more quickly reached in this way.

In extensive impassable strictures of the lower part of the œsophagus gastrostomy is to be recommended, as in such cases the nourishment of the patient by means of nutritive enemata is usually insufficient. Through the opening in the stomach one can sometimes dilate the stricture with permanently good results. The method recommended by Socin, Hagenbach, Kraske, Gissler, the author, and others, is as follows: The patient is given a shot to swallow, which is fastened to a fine thread. The thread is then drawn out through the hole in the stomach. A stronger silk thread is then attached to the other and drawn up through the œsophagus. The two ends which now protrude, one of them through the mouth and the other through the hole in the stomach, are then tied together. By the aid of this thread, which remains in place, œsophageal bougies of rapidly increasing diameter are drawn upward through the œsophagus. The gastric fistula is closed after the stricture has been cured. If the stricture can be reached by the finger passed into the stomach, the former may be dilated by means of the forefinger or a blunt urethrotome; a bougie is then passed into the stomach through the mouth, and a thread drawn out through

the œsophagus for subsequent retrograde dilatation. Franks collected from literature twenty-one successful cases treated by this method.

For the technique of internal and external œsophagotomy, œsophagostomy, and resection of the œsophagus, the reader is referred to § 114, pages 654, 655 ff. The technique of gastrostomy is described in § 165 (Surgery of the Stomach).

The treatment of compression strictures depends largely upon their cause. In case of spasmodic strictures the frequent introduction of an œsophageal bougie is to be recommended, as well as the internal administration of bromide of potassium, hypodermic injections of morphine, etc. Above all, one must try to discover the underlying cause of the existing "nervous condition."

Boeckel has treated deep cicatricial strictures of the œsophagus near the cardiac orifice by electrolysis when they are impassable for bougies. His method has been as follows: A small copper cone was fitted to the lower end of an œsophageal tube, and from this ran the conducting wire inside the tube to the negative pole of the battery. The positive pole in the form of a plate was placed to the left of the vertebral column, on a level with the eighth rib. The copper cone was carried down to the stricture. Weak and medium-strength currents were applied, the duration of each sitting being from two to five minutes. The strictures became passable even after from one to three sittings, and could then be further dilated by means of bougies. J. A. Fort also recommends the electrolytic treatment of strictures. The positive pole is placed upon the abdominal wall, and the negative electrode, prepared especially for this purpose, is introduced into the œsophagus for a few minutes down to the stricture.

§ 112. **Dilatations and Diverticula of the Œsophagus.**—The dilatations of the œsophagus either involve a large part of the tube, or they are more circumscribed, forming the so-called diverticula.

The uniform dilatations are most frequently observed above strictures in the lower part of the œsophagus, resulting from the accumulation of food above the constriction. Such dilatations are also formed independently of strictures in consequence of a diminution in the contractile power of the walls of the œsophagus—e. g., after inflammations with thickening or thinning of the wall, especially of the muscular layer. In rare cases congenital dilatations occur—e. g., above the point where the œsophagus passes through the diaphragm (Zenker) and above the cardiac orifice. Besides these circumscribed congenital dilatations, congenital dilatations of the entire œsophagus are also observed, sometimes of very marked extent, so that the œsophagus is twice as long and twice as wide as normal. The œsophagus has even been found to have in places a diameter equal to that of an arm. When a uniform dilatation bulges out at one point, a diverticulum may result.

Leichtenstern observed a sacculated dilatation of the œsophagus in the case of a hysterical girl of twenty, which resulted from spasmodic stricture of the cardiac orifice, owing to a disturbance in innervation. In consequence of this spasm of the cardiac orifice the food collected just as in a crop. Strümpell observed a very similar case. Besides these iodopathic circumscribed dilatations there are also idiopathic, sacculated, and spindle-shaped dilatations at the lower end of the œsophagus without stricture or spasmodic closure of the cardiac orifice.

The symptoms of uniform dilatation of the œsophagus vary according to its degree. If it is the result of a stricture, the latter produces the principal symptoms, which consist in dysphagia with subsequent regurgitation of the food accumulated above the stricture. Serious disturbances in nutrition may gradually develop in marked cases of dilatation without stricture, as the food that has been swallowed remains in the œsophagus, and is after a time regurgitated. Such dilatations of the œsophagus filled with food may occasion respiratory disturbances by pressure upon the trachea and the lungs. Sometimes the sac filled with food may be felt from the outside.

Special treatment of dilatations, aside from that of a coexisting stricture, is scarcely possible. Generally speaking, the treatment will confine itself to suitable nourishment of the patient.

Diverticula of the œsophagus—that is, circumscribed dilatations of the œsophageal wall—may be classified, according to Zenker, as pressure and traction diverticula.

Traction diverticula arise in consequence of a force acting from without, and are found chiefly on the anterior wall of the œsophagus about on a level with the bifurcation of the trachea. They are caused most frequently by adhesion of the œsophageal wall with the adjacent parts in consequence of inflammatory processes, especially in the lymph glands, by which the wall is drawn outward. Such traction diverticula have the form of funnel-shaped depressions of the mucosa and submucosa or shallow cavities, whose bottom is intimately attached to the trachea, the bronchi, or contracted bronchial glands by means of dense connective tissue. This form of diverticulum does not, as a rule, increase in size, but may occasion the incarceration of any foreign body that has entered it, and thereby cause perforation. Leichtenstern observed perforation of a traction diverticulum of the œsophagus into the lung and death from pulmonary gangrene.

Zenker's pressure diverticula arise from pressure from within, which causes a bulging outward of the œsophageal wall. They are of rare occurrence. Their location, or rather that of their orifice, is most frequently in the pharynx, just above the beginning of the œsophagus,

and these diverticula have therefore also been called pharyngoceles. Pressure diverticula are of greater clinical importance than traction diverticula. Their size is very variable. They may, for example, be no larger than a pea or a hazelnut or walnut, or they may form large spherical, pear-shaped, or cylindrical sacs, which lie between the œsophagus and the vertebral column, and sometimes extend far downward. Such pressure diverticula are really herniæ of the mucous membrane. Their wall consists of mucous membrane and submucosa, which have forced their way between the muscular fibres, most frequently those of the inferior constrictor muscle of the pharynx. Pressure diverticula develop by preference at some part of the posterior pharyngeal wall, because in case of diminished power of resistance this most easily yields to pressure during the act of swallowing. The exciting causes are injuries, or a foreign body that has become tightly lodged.

A specimen of a pressure diverticulum described by König is of especial interest. It shows how large such a diverticulum may become (Fig. 338). This specimen, which is in the Göttingen collection, is from an elderly person of whose history no particulars are known. The large sac of the diverticulum (D), which is twelve centimetres long, extends downward beyond the bifurcation of the trachea. Its orifice lies in the pharynx directly above the entrance to the œsophagus, and is so wide that one can easily introduce the forefinger. The inner surface of the sac is lined with smooth mucous membrane, and the outer surface has a distinct muscular covering.

Fig. 338.—Diverticulum (*D*) of the pharynx above the entrance to the œsophagus; *Tr*, trachea; *o*, œsophagus (König).

Pressure diverticula are far more common in men than in women. Of twenty-nine cases, according to Zenker, only two were found in women.

The course of pressure diverticula is usually extremely chronic. They enlarge very gradually in the course of years by the constant deepening of the original depression, and in this way develop in from ten to twenty or thirty years into a larger or smaller sac. The food that enters such a sac naturally remains there for a long time and becomes decomposed. When the sac has become filled with food, the

latter is finally regurgitated by means of the muscles of the neck, and by retching. Other symptoms of diverticula, aside from this regurgitation of food, are the appearance of a swelling in the neck, the perception of sounds resulting from the collection of air and fluids in the sac, and symptoms of pressure of the distended sac upon the air passages and upon the vessels and nerves. When an examination is made with an œsophageal bougie the latter tends to pass into the diverticulum. In severe cases the patient may die, after years, from inanition resulting from the diverticulum.

The treatment of diverticula is essentially of a palliative nature, consisting in proper feeding of the patient, through the stomach tube it may be, or by means of nutritive enemata. In suitable cases a radical operation upon the diverticulum—i. e., its extirpation with subsequent suture—should be attempted, as König also suggests. One would in this case expose the neck of the sac from the outside, free the diverticulum from the surrounding connective tissue, cut it away, and close the defect in the œsophagus or pharynx with catgut sutures after inverting its edges. Kocher tied the pedicle of the sac in two places, divided it with the thermo-cautery, cauterized the mucous membrane, and covered the stump by suturing the œsophageal wall over it longitudinally. Bergmann, Bayer, and others, after removal of the sac, insert a permanent tube into the stomach through the wound; the pharynx and œsophagus are sutured around the tube and the external wound is packed. After removal of the permanent tube on the fourth or fifth day, the stomach tube is passed through the mouth.

§ 113. **Tumours of the Œsophagus.**—The carcinoma is the most common of the tumours of the œsophagus, and is found chiefly in the form of an epithelioma with pavement cells. The œsophageal carcinoma seems to develop by preference in those parts of the œsophagus which are normally constricted, and at which, therefore, the food may occasion slight, to be sure, but frequent mechanical irritation. Such favourite locations of the œsophageal carcinoma are the juncture of the pharynx with the œsophagus, its passage through the diaphragm, and especially the neighbourhood of the cardiac orifice. As a rule, the carcinoma gives rise to circumscribed growths often circular in form which include the entire circumference of the organ. Later on they break down and ulcerate, spread to the adjacent parts (trachea, bronchi, lungs, pleura, pericardium, heart, diaphragm, etc.), and frequently lead to perforation of the œsophagus. Men, especially drinkers, are affected, according to Zenker, seven or eight times as frequently as women. Among 15,168 autopsies in the pathological institute at Munich, there were, according to Rebitzer, twenty-five cases of primary and four

cases of secondary carcinoma of the œsophagus, making 0·18 per cent of all autopsies. Of these twenty-nine cases, twenty-one were men and eight women. Most of them were between forty and seventy years of age. In the majority of cases the lower end of the œsophagus was affected.

The principal symptom of cancer of the œsophagus is dysphagia, resulting from the stricture, with increasing emaciation, as we have already described it (§ 111, pages 643–645) when treating of strictures. The usual duration of the disease is from one to at most two years. Death ensues from inanition and increasing cachexia, or from perforation of the œsophagus with secondary septic phlegmon; or, finally, from perforation into the lungs, the pleural cavity, the pericardium, or the large vessels, etc.

The diagnosis of cancer of the œsophagus can usually be made when in an elderly person gradually increasing dysphagia appears without any apparent cause, and the examination with the œsophageal bougie reveals a stricture. Cancer cells are often found in the vomited matter or in the eye of the œsophageal tube.

The treatment of cancer of the œsophagus, owing to the fact that patients usually seek surgical aid too late, is for the most part symptomatic only—that is, it is directed against the stricture and the inanition. For the treatment of strictures the reader is referred to pages 646–649 ff.

If the carcinoma has an accessible location in the region of the neck it should be removed. Czerny first, in the case of a man fifty-one years of age, successfully resected a portion of the œsophagus six centimetres long which was the seat of a carcinoma. The incision through the skin was made from the hyoid bone to the manubrium of the sternum. As the two ends of the œsophagus were afterward too far apart to be united by suture, the lower end was sutured into the wound and the patient was fed through this fistula. Menzel and Czerny have resected pieces from the continuity of the œsophagus in dogs, and secured union of the ends after suture without stricture. In suitable cases, following the procedure of Hacker and Poulsen, the skin of the neck may be used to replace the resected portion of the pharynx or the œsophagus (see page 657).

In inoperable cases of carcinoma of the œsophagus the only remaining possibility is to make a fistula in the neck or the stomach through which the patient is fed. (For the technique of œsophagostomy, see page 656; for that of gastrostomy, § 165.)

The other new growths of the œsophagus are, in comparison with carcinoma, very rare. Fibromata, lipomata, myxomata, and sarcomata

have been observed. The most frequent fibromata are those which originate in the lower part of the pharynx, as polypous growths, and hang down into the œsophagus, and are constantly drawn down more and more by the movements of swallowing. In this way the pedicle of the tumour may constantly become longer, and the tumour itself hang far down into the œsophagus, although it originates in the pharynx.

One also observes in rare cases, aside from these polypous growths, warty, papillary excrescences which often change into carcinomata. König mentions a congenital dermoid cyst as a very rare new growth.

The symptoms resulting from the tumours of the œsophagus that have been mentioned become marked only when they have reached a certain size. Here also the main symptom is dysphagia, in consequence of the space taken up by the tumour. Polyps with long pedicles located in the pharynx and upper part of the œsophagus may be displaced upward into the pharynx by regurgitating movements, and, by closing the superior aperture of the larynx, occasion attacks of suffocation. Death from suffocation has in fact been caused in this way.

The diagnosis of the above tumours is made especially from the symptoms that have been described and from examination with the œsophageal bougie. The presence of tumours in the lower part of the pharynx and at the entrance to the œsophagus may be made out by direct palpation or by laryngoscopy. They may also be displaced upward by gagging movements caused by irritation of the pharynx, and thus become directly visible.

The treatment of this class of tumours of the œsophagus conforms essentially to the same rules that have been given for the treatment of carcinomata. Subhyoid pharyngotomy (see page 440) may come into consideration in connection with tumours that are situated high up in the lower part of the pharynx and the beginning of the œsophagus. Middeldorff recommends that the polyps that are situated high up and have a long pedicle be brought up into the mouth by inciting regurgitation, then quickly seized with a volsellum forceps, drawn toward the corner of the mouth so as to lessen the asphyxia, and finally ligated and divided in front of the ligature with the knife or curved scissors or by means of the galvano-cautery. Polyps situated lower down and other non-malignant tumours may also be removed through the neck after performing external œsophagotomy.

§ 114. **Operations on the Œsophagus.**—The operations on the œsophagus are internal and external œsophagotomy and the resection of a portion of the œsophagus in its continuity.

By internal œsophagotomy is understood the division from the inside of membranous or cicatricial strictures of the œsophagus which

can not be overcome or ameliorated by gradual dilatation by means of bougies. Internal œsophagotomy was employed particularly by Trélat and Maisonneuve and with good results. It is now less frequently performed. Trélat and Maisonneuve devised the best instruments for this operation, which are much the same as those used for internal urethrotomy. The œsophagotome, containing a covered knife blade, is usually passed through the stricture, and on drawing the instrument out the stricture is divided by the projecting blade. The blade can be so regulated as to avoid accessory injuries and too deep incisions. On the third or fourth day after the operation dilatation with bougies should be begun in the manner described on pages 646, 647.

External œsophagotomy—i. e., opening the cervical portion of the œsophagus from the outside—is performed chiefly for the removal of foreign bodies and for strictures of the œsophagus. The operation is performed on the left side of the neck somewhere between the cricoid cartilage and the manubrium of the sternum, because the left border of the œsophagus projects a little beyond the trachea. If, however, a foreign body, for example, should be more distinctly felt upon the right side, the incision should be made on that side of the neck.

Anatomically it may be mentioned that the commencement of the œsophagus lies somewhat below the cricoid cartilage. On a level with the sixth cervical vertebra the œsophagus is crossed by the inferior thyroid artery. The superior laryngeal artery runs in a similar way obliquely across the pharynx farther up. The recurrent laryngeal nerves run, as is known, in the space between the trachea and the œsophagus. In cases of abnormal origin of the right common carotid and the right subclavian arteries from the arch of the aorta these vessels have been found to pass up behind the œsophagus and likewise cross it.

External œsophagotomy is performed with the patient in a half-sitting posture, the head being turned to the right. As a guide during the operation, a large-sized œsophageal tube or a metallic catheter is inserted as low down as possible into the œsophagus. The incision through the skin (Fig. 339), which is from five to seven centimetres long, is made in much the same way as that for ligation of the common carotid artery. It begins about on a level with the cricoid cartilage, passes along the inner border of the sterno-mastoid muscle, and ends a little above the manubrium of the sternum. After dividing the skin, the platysma, and the superficial fascia, the external jugular vein being left intact, the sterno-mastoid muscle is drawn outward by means of a blunt retractor. The middle layer of the cervical fascia is now divided, with or without preservation of the omo-hyoid muscle. The lateral lobe of the thyroid gland is then laid free and drawn

inward by means of a blunt retractor. If there is a goître, the enlarged lobe of the thyroid gland must be thoroughly exposed, and the superior thyroid artery tied in two places and divided. If now the large vessels of the neck that are exposed, together with the pneumogastric nerve and the descending branch of the hypoglossal nerve, are likewise drawn outward by means of the outer retractor, one comes upon the œsophagus farther in, which can easily be felt on account of the previously inserted tube. The height at which the œsophagus is to be opened by a longitudinal incision depends upon the location of the foreign body or the stricture. The foreign body is then extracted through the wound in the œsophagus by means of suitable forceps, or the stricture is dilated by introducing forceps, or, if necessary, divided. Gussenbauer inserts a grooved director and cuts the stricture with a herniotomy knife.


Fig. 339.—External œsophagotomy.

The after-treatment following external œsophagotomy is somewhat as follows: After the extraction of the foreign body or after dilatation of the stricture, an œsophageal tube, which is best introduced through the nose, is passed into the stomach and allowed to remain for the sake of feeding the patient. The wound in the œsophagus may be left open, or, better, closed by continuous catgut sutures. The external wound is not sutured, but is packed with iodoform gauze. The œsophageal tube may also be introduced through the wound into the stomach, and in this case also the external wound is packed with iodoform gauze. The tube is removed in eight or ten days after the wound has begun to granulate well.

The course is usually favourable. Healing generally takes place in from three to six weeks if complicating injuries and inflammations did not exist previous to the operation.

If one desires to make a permanent fistula below a stricture that is situated high up in the œsophagus or in the pharynx, for the sake of feeding the patient through the œsophageal tube, the edges of the wound in the œsophagus after external œsophagotomy has been performed, should be sutured to the inverted edges of the skin (œsophagostomy). A tube made of aluminium, or preferably silver, may be

inserted into this artificial opening. By the addition of a funnel, the food, having been first masticated by the patient, passes down into the stomach.

Circumscribed carcinomata located in the cervical portion of the œsophagus may be extirpated by removing the diseased portion of the œsophagus, after Czerny, as was mentioned on page 653 (Resection of the Œsophagus).

This resection of the œsophagus is only indicated in those cases of localized carcinoma which have not yet passed beyond the œsophageal wall. If the upper and lower ends of the œsophagus can not afterward be united by catgut sutures, one may, after Hacker and Poulsen, use the skin of the neck to supply the place of the resected portion of the pharynx or œsophagus, or the lower end may be sutured to the outer skin, and in this way an œsophageal fistula formed for the artificial feeding of the patient with the œsophageal tube.

In cases of extensive carcinomatous growths in the upper part of the œsophagus, Iversen has successfully excised the latter or the pharynx and the larynx. Low tracheotomy is first performed and the pharynx is immediately opened by subhyoid pharyngotomy (see § 70, page 440). A vertical incision is then made downward over the middle of the larynx to a point from one to one and a half centimetres above the tracheotomy wound. Then follows detachment of the larynx (see § 106) and resection of the pharynx or the upper part of the œsophagus, after its distal end has been secured by means of silk threads.

Œsophagoplasty.—As was mentioned above, one may, after resection of the pharynx or the œsophagus—e. g., after complete extirpation of the larynx and resection of the upper part of the œsophagus—remedy the defect in the latter by skin-flaps (Hacker, Poulsen, Hochenegg). The posterior wall of the œsophagus is first constructed by means of two lateral skin-flaps which are united by suture on each side with what remains of the œsophagus. A month or two later a flap is taken from one side of the neck, turned over with the epidermis on the inside, and sutured to the opposite side of the œsophageal gutter. The whole is then covered finally with a flap taken from the side of the neck.

For a description of gastrostomy, see § 165 (Operations on the Stomach).

THIRD SECTION.

SURGERY OF THE THORAX.

CHAPTER XIII.

INJURIES AND DISEASES OF THE THORAX.

Congenital and acquired deformities of the thorax (malformations).—Injuries of the thorax: Contusions.—Concussion of the thorax.—Fractures and dislocations of the sternum, the ribs, and the costal cartilages.—Wounds of the thorax.—Wounds of the long thoracic artery, the internal mammary artery, and the intercostal arteries.—Ligation of the internal mammary artery.—Penetrating injuries of the thorax: Injuries of the pleura, the lungs, the pericardium, the heart, and the large vessels.—Injuries and diseases of the thoracic duct.—Injuries and diseases of the diaphragm.—Inflammatory processes on the thorax: Inflammatory processes in the soft parts and in the bone.—Tuberculosis and syphilis of the ribs and sternum.—Resection of the ribs and the sternum.—Intercostal neuralgia.—Inflammatory processes within the thorax and their surgical treatment (pleura, lungs, pericardium, mediastinum).—Paracentesis and thoracotomy with resection of the ribs.—Puncture and incision of the pericardium.—The surgical treatment of abscess of the lung.—Mediastinitis.—Tumours of the chest wall and the thoracic cavity (pleura, lungs, pericardium, mediastinum).—Aneurisms of the thoracic aorta.

§ 115. **Congenital and Acquired Deformities of the Thorax (Malformations).**—The deformities of the thorax are in part congenital and in part acquired.

Of congenital deformities or malformations proper of the thorax we mention first those of the sternum.

The sternum may be partially or wholly wanting. In the latter case one finds in its place a firm, fibrous tissue. Sometimes only half the sternum is present—e. g., it is found only on one side, so that on the other side the ribs end free. There are also various fissure formations and defects in the sternum. These fissures are found especially in the upper part of the sternum or in the ensiform process. Complete longitudinal fissures have been observed, resulting in the formation of two distinct halves, which separate still more during inspiration. In one case, reported by H. Fischer, the amount of separation at the manubrium of the sternum was six centimetres during inspiration and four centimetres during expiration.

The malformations of the sternum are sometimes combined with those of the entire thorax, with curvature of the spinal column, and with partial or complete abdominal fissure. These are really to be regarded as arrested de-

velopments resulting from incomplete closure of the thorax or the visceral plates. All malformations of the sternum are of significance with reference to possible injuries and operations. A special treatment is usually impossible.

Congenital "funnel-breast" (Ebstein)—that is, the funnel-shaped depression of the lower part of the sternum and the upper and middle abdominal region—probably has its origin in a defective fœtal development of the sternum. According to Zuckerkandl, the pressure of the lower jaw of the fœtus is of significance in the development of this malformation, whereas Hagmann thinks that it is due to pressure of the heel.

Congenital deformities of the ribs are without special interest—e. g., adhesions or fissures of the ribs, incomplete development or absence of this or that rib. The absence or incomplete development of the twelfth rib is, however, of practical importance, as we shall see, in connection with operations in the region of the kidney.

Congenital muscular defects are rare. Stintzing has collected from literature thirteen cases of absence of the pectoralis major muscle. Kredel observed in a boy of twelve years congenital absence of the pectoralis major and the serratus anticus major on one side. In their place a membrane stretched between the chest and the upper arm like a web. Riedinger properly emphasizes the fact that congenital muscular defects and those that are acquired—e. g., in consequence of progressive muscular atrophy, may easily be confounded.

Acquired deformities of the thorax result from wounds and diseases of the thorax and the spinal column—for example, scoliosis and kyphosis of the vertebral column, empyema, and especially rhachitis. Among changes in the form of the thorax caused by rhachitis, pigeon-breast (pectus carinatum, see Fig. 340) is the most common.

Fig. 340.—Extreme pigeon breast (pectus carinatum) with paralytic lordosis and kyphosis of the spine resulting from rhachitis and idiopathic dislocation of both hips (Schreiber).

Its characteristics are a projection of the sternum like the keel of a boat, sinking in of the ribs, and depression of the sides of the thorax. The lateral diameter of the thorax is therefore stikingly diminished. Dupuytren, Warren, Robert, Phocas, and others have called particular attention to the fact that rhachitic pigeon-breast develops by preference in those children who are compelled to strain unduly their respiratory muscles in consequence of hypertrophy of the tonsils, adenoid growths in the naso-pharynx, etc.

The treatment of rhachitic pectus carinatum is only successful when it is undertaken very early, while the rhachitis still exists. It is of the greatest

importance that the children remain lying down. The rhachitis is treated in accordance with general rules (see Principles of Surgery, § 108, page 643). In addition to appropriate constitutional treatment of a strengthening character, suitable lung exercises are beneficial.

Regarding changes in the form of the thorax in connection with scoliosis and kyphosis, after empyema, etc., the reader is referred to the corresponding paragraphs. There remain to be mentioned here only changes in the form of the lower portion of the thorax with disturbances on the part of the thoracic and abdominal organs, in consequence of too tight lacing, and the retraction of the ensiform process in children as the result of deep and forced inspiratory movements necessitated by hypertrophied tonsils or adenoid growths in the naso-pharynx, and temporarily in connection with every stenosis of the larynx, resulting from diphtheria, for example.

Hernia of the Lung.—By a hernia of the lung is understood the protrusion of a portion of a lung from the thorax, through a gap, for example, in the intercostal muscles, so that it comes to lie beneath the skin. Herniæ of the lung have also been observed on the neck in the supraclavicular fossa in the form of tumours as large as a pear or an apple. These result from dilatation of the emphysematous apices of the lungs (Cockel, Morel-Lavallé). Herniæ of the lung are very rare. They occur after subcutaneous injuries, whooping-cough, emphysematous dilatation of the lungs, etc. Prolapse of the lung through an open wound in the thorax has likewise been designated as traumatic hernia of the lung, but the name "traumatic prolapse of the lung" is more correct. The so-called idiopathic herniæ of the lung also arise from increased expiratory pressure or increased volume of the lung as the result of severe coughing or a violent muscular effort, or in connection with emphysema and chronic bronchitis. In idiopathic herniæ the lung is forced out, in consequence of increased expiratory pressure through weak places, especially in the anterior thoracic wall through the seventh, eighth, and ninth intercostal spaces, also in the neighbourhood of the points of insertion of the costal cartilages on to the bony part of the ribs, and in the upper thoracic aperture (Morel-Lavallé, Strübing). Idiopathic hernia of the lung is sometimes constant and sometimes intermittent—that is, it disappears from time to time. Hernia of the lung is in some cases congenital. Ectopia of the lung is to be distinguished from congenital hernia. In the former we have to do with a congenital abnormal displacement of a portion of the contents of the thorax or of a portion of the lung outside the thoracic cavity, and not with a protrusion of lung tissue through a pathologically enlarged but normally existing opening (Hochsinger).

A hernia of the lung usually forms a soft, tympanitic tumour, over which vesicular breathing is heard. As a rule, a hernia of the lung can be easily replaced, and has afterward to be held back by a proper bandage. In suitable cases the thoracic cavity should be closed by a radical operation. The treatment—e. g., in idiopathic hernia—should be directed against the cause, chronic bronchitis and emphysema, for instance, conditions which often, unfortunately, can not be cured.

§ 116. **Injuries of the Thorax.**—The first of the injuries of the thorax to be mentioned are subcutaneous injuries or contusions, re-

sulting from the action of blunt violence—e. g., a kick or blow, being run over, being buried up, etc. We distinguish with Riedinger contusion of the thorax from concussion of the same. In the former, organic changes resulting from the injury are always demonstrable, whereas this is not the case in the latter, although very severe symptoms may be present.

The simplest contusions of the thorax are bruises of the soft parts, with subcutaneous extravasations of blood, while the thoracic organs remain intact. There are sometimes subcutaneous lacerations of the muscles—e. g., of the pectoralis major. The course, as in all subcutaneous injuries of the soft parts, is usually favourable. The treatment consists in the application of ice, in compression with elastic bandages, and especially in massage. If there is delay in the absorption of large subcutaneous extravasations of blood, one may make an aseptic incision, and in this way let out the blood that has collected.

Severe contusions of the thorax—e. g., from being run over, from falling a great distance, from being buried up, etc.—are often combined with injuries of the thoracic contents, particularly the lungs, the heart, the large vessels and nerves, the trachea, the œsophagus, and the diaphragm, and finally with fractures of the sternum, the ribs, the spinal column, etc. The outer coverings may remain wholly intact in spite of the action of such great violence, but death may follow immediately from rupture of the lungs, the heart, the large vessels, or the diaphragm. Rupture of the pleura and the lungs occurs in many cases in consequence of compression of the thorax while the glottis is closed.

The symptoms of these severe contusions of the thoracic organs consist, in case of injury to the lungs and pleura, in a corresponding collection of blood and air in the thorax (hæmothorax, pneumothorax, hæmopneumothorax), and in hæmoptysis. There is sometimes a circumscribed or more general, more or less rapidly increasing accumulation of air in the subcutaneous cellular tissue (emphysema). Langwagen, as is mentioned by Riedinger, observed emphysema of the skin in the hypogastric region in the case of a trumpeter after every violent effort at blowing. Subcutaneous prolapse of lung tissue sometimes occurs—so-called traumatic hernia of the lung—especially if the ribs are fractured.

The outcome of subcutaneous injury of the lungs depends mainly upon the degree of the laceration or of the respiratory disturbances caused by the injury and the subsequent hæmorrhage. In case of recovery, the blood and air in the pleural cavity are gradually absorbed or evacuated by thoracocentesis or thoracotomy. If empyema develops in consequence of infection by microbes from the lungs, the

pus must be removed as quickly as possible by means of thoracotomy and drainage.

In rupture of the heart, an effusion of blood into the pericardium takes place (hæmopericardium), and if the latter is not ruptured as well, death from paralysis of the heart follows very quickly in consequence of the pressure of the blood that collects in the pericardium. Ruptures of the heart are, moreover, favoured by any degeneration of the cardiac muscle that may exist. If the large vessels outside the pericardium are ruptured, death follows very quickly from internal hæmorrhage.

Regarding injury to the œsophagus and the trachea, see Surgery of the Neck, §§ 88, 92, 93, pages 504, 530, and 535.

If there is a rupture of the diaphragm, death may ensue in consequence of interference with respiration caused by the abdominal organs that have entered the thorax (stomach, intestines, or liver). The abdominal organs also are not infrequently severely injured, and one finds at the autopsy contents of the stomach and intestine, fragments of the liver, etc., within the pleural cavity. If the stomach or intestine has entered the thorax through a hole in the diaphragm, the symptoms are essentially those of pneumothorax. One sometimes observes strikingly slight functional disturbances of the lungs and heart in spite of the fact that the stomach, the intestine, and parts of the liver lie in the thoracic cavity. Patients even survive the injury and live on for many years with their rupture or hernia of the diaphragm, without appreciable interference with respiration (see also § 194, Diaphragmatic Herniæ). In such cases death has sometimes occurred later in consequence of injury to the intestine or stomach lying in the thoracic cavity—e. g., from an aspirating needle. It follows from this that one should always examine the thorax very carefully before aspirating it.

Treatment of severe contusions of the thorax is, as a rule, scarcely possible. Death very frequently follows immediately or soon after the accident before medical assistance is at hand. The treatment is mainly of a symptomatic nature. In case of hæmothorax and hæmopericardium, with corresponding interference with respiration and the action of the heart, one should first of all remove the blood that has collected in the pleural cavity and in the pericardium by aspiration or an incision (see the technique of these operations, §§ 126, 127, pages 701–711). The remainder of the treatment consists in keeping the patient quiet and prescribing a suitable diet. In case of collapse, stimulants and wine are given internally, ether is administered hypodermically, etc. For the treatment of associated injuries of the trachea,

the œsophagus, and the abdominal organs, see under their respective headings.

Concussion of the Thorax.—This rare form of injury to the thorax has been recently studied in detail, particularly by Riedinger. It results from the action of the same sort of violence as contusion, particularly from a kick, a blow, or a fall from a height, and occurs without demonstrable injuries. One sometimes, however, observes severe symptoms—e. g., after a blow upon the sternum, and death even is said to have followed from shock without the existence of any appreciable injury to the internal organs.

Meola and Riedinger have made a careful experimental study of thoracic concussion. Light blows upon the thorax are without special result. A slight lowering of the blood pressure follows each blow. When the blows upon the thorax are severe, however, there is marked diminution of the blood pressure, the respiration becomes irregular, short, and rapid, and the animal experimented upon becomes unconscious. Riedinger explains the severe symptoms or even the fatal result attending extreme thoracic concussion, without appreciable organic injury, by the lowering of the blood pressure in consequence of intrathoracic stimulation of the pneumogastric nerve and direct concussion of the heart, and to a slighter degree by defective circulation within the brain in consequence of diminished blood pressure. According to Riedinger, paralysis of the heart in diastole may result from violent concussion of the same.

In man, severe cases of thoracic concussion with lowering of the blood pressure, irregular respiration, great pallor, unconsciousness, and death even, as observed in the experiments, are surely exceptional, but I do not venture to question their occurrence. As a rule, we have to do in man with contusions of the thorax combined with organic injury or with combinations of contusion and concussion. In case of thoracic concussion the patient usually recovers very soon after the injury. The symptoms that have just been mentioned disappear in a few hours or days.

The diagnosis of thoracic concussion can be made if the severe cardiac, respiratory, and cerebral symptoms that have been mentioned are present, and at the same time no appreciable injuries are demonstrable.

In treating this condition Riedinger recommends that the cerebral anæmia resulting from the lowering of the blood pressure be combated by putting the patient in a horizontal or oblique position with the head lowered. If the breathing is irregular, artificial respiration should be begun. Moreover, wine may be given, ether injected hypodermically, and the body massaged.

§ 117. **Fractures and Dislocations of the Sternum.**—Fracture of the sternum is, in spite of the superficial location of the bone, a very rare injury—the rarest of all fractures, in fact, because it has such an elastic insertion between the costal cartilages. Messerer placed a weight of from forty to sixty kilogrammes upon the sternum of a young subject and thus forced it in as far as the vertebral column without breaking it. Fractures of the sternum occur most frequently from indirect violence by which the trunk is bent too far forward or backward. Indi-

rect fractures of the sternum also arise from a fall or blow upon the head by which the chin is pressed against the manubrium of the sternum, and from a fall upon the shoulder. Tearing off of the ensiform process and transverse fractures of the manubrium of the sternum have also been observed in consequence of muscular action following, for example, violent contractions of the abdominal muscles in lifting heavy weights, also in women during labour or in vomiting. If the vertebral column is unduly stretched by being bent over backward and the sternum thus fractured by being torn apart, the contraction of the muscles is here also of importance.

Fractures from direct violence, which are less frequent, are observed in run-over accidents and from being crushed by the buffers of railway carriages, etc.

Transverse or slightly oblique fractures of the upper and middle portions of the body of the sternum are most common. Those of the lower part of the body, the manubrium, and the ensiform process are less frequent.

In a transverse fracture there may be no displacement whatever. If there is any, the lower fragment is most commonly carried forward and pushed upward upon the upper fragment. Displacement in which this is reversed, or an angular displacement with the apex pointing backward, has also been observed.

If the division of the bone occurs in the articulation of the body of the sternum with the manubrium and ensiform process, the injury is designated as diastasis or dislocation.

The fracture is sometimes incomplete. One then finds a fissure on the anterior or posterior surface of the sternum. In a few cases longitudinal fractures of the sternum have been observed.

Fractures of the sternum—being caused, as a rule, by great violence—are usually complicated with other severe injuries, especially fractures of the ribs, the clavicle, the spine, and the pelvis, and also, above all, with injuries of the thoracic and abdominal organs. The most frequent injuries within the thorax are those of the pericardium, the heart, and the lungs. Large extravasations of blood may also take place into the mediastinum, particularly from laceration of the internal mammary artery and vein (hæmomediastinum).

The symptoms of a fracture of the sternum are usually so distinct, especially when there is a displacement of the fragments, that the diagnosis is not difficult. It can only be a question between fracture and dislocation at the articulations of the body of the sternum with the manubrium and the ensiform process. If the usual above-mentioned displacement exists, one sees at once the abnormal projection or depres-

sion on the sternum. The fragments sometimes move back and forth perceptibly during respiration, or they may override. The head and neck of the patient are usually held stiff and inclined forward, and every attempt to straighten the body or to take a deep breath is avoided on account of the great pain attending it. Crepitus can be best demonstrated, in case the fragments are not displaced, by placing the hand or a stethoscope over the fracture while the patient takes a deep inspiration. The patient often says that he distinctly felt or heard a breaking of the bone at the time of the fracture.

The prognosis of simple uncomplicated fractures of the sternum is usually favourable. They unite, as a rule, by the formation of a bony callus within four weeks without functional disturbance. If the fracture heals with deformity from marked displacement of the fragments, functional disturbances may arise, especially dyspnœa, coughing, and palpitation of the heart in consequence of diminution of the space within the thorax and compression of one or both phrenic nerves. Ritter observed mitral stenosis resulting from injury to the heart after mal-union of a fracture of the sternum.

The above-mentioned secondary injuries, especially those of the lungs, the heart, the internal mammary artery, the spine, the spinal cord, etc., decide the outcome of a fracture of the sternum. Great danger may also arise from suppuration, extending to the mediastinum, the pericardium, and the pleura, resulting from the non-aseptic treatment of compound fractures of the sternum (see also Penetrating Injuries of the Thoracic Organs, page 673).

The treatment of fractures of the sternum in which there is no displacement is very simple. The patient must keep as quiet as possible and avoid all undue movements of the thorax. Compound fractures are treated, of course, with strict antiseptic precautions (see Principles of Surgery, page 597).

If there is a displacement, an attempt should be made to reduce it —e. g., by pressure upon the fragment that is dislocated forward, by hyperextension of the spinal column, etc. It is a very good plan to lay a roller cushion under the back of the patient or to place him in a Rauchfuss's hammock (see Fig. 406, page 819). It is generally difficult to keep the fragments in their normal place after reposition, as the displacement easily recurs. But even though the fragments do heal in a displaced position, as a rule no functional disturbances result and bony union follows. Only in case there are severe disturbances—e. g., of the heart and the lungs—in consequence of extreme deformity at the site of fracture, should the latter be exposed, under antiseptic precautions, and the position of the fragments improved by suturing, wiring, or resecting them. If, in connection with compound fractures, suppuration ensues, especial care must be taken to avoid burrowing of pus in the direction of the mediastinum and the pleura.

For the treatment of complications, especially injuries of the lungs, the heart, the internal mammary artery, the spinal column, etc., see the corresponding paragraphs.

Dislocations of the Sternum.—Diastases or dislocations of the body from the manubrium of the sternum are included by many authors among fractures. The same is true of dislocations of the ensiform process. At all events, fractures and dislocations of the sternum arise from the same causes. According to Rivington, dislocations of the body from the manubrium are more frequent than the fractures proper. The symptoms are precisely the same as those of fracture. In dislocation, also, the body is usually carried in front of the manubrium. Petersen observed a dislocation in the joint between the body and manubrium simultaneously with one between two upper dorsal vertebræ—i. e., there was a displacement of the upper from the middle portion of the thorax.

The treatment of diastases or dislocations of the sternum is essentially the same as that given on page 665 for fractures of the sternum.

§ 118. **Fractures and Dislocations of the Ribs.**—The very elastic and sharply curved ribs are firmly inserted between the sternum and the dorsal vertebræ. The seven upper ribs are directly connected with the sternum, while the connection of the eighth to the tenth rib with the sternum is indirect, as each of these ribs is joined to the lower edge of the one next above it. The eleventh and twelfth ribs end free.

In consequence of their great elasticity and their compact structure, the ribs are able to withstand the action of a considerable force. The ribs of children have the greatest elasticity, and the latter diminishes with increasing years. The thorax of children can be compressed by placing weights on the sternum until it is brought in contact with the spinal column without causing a fracture. On the contrary, the ribs rebound like springs into their normal position as soon as the pressure ceases. Messerer produced a fracture of the ribs on the cadaver of a strong man of thirty years only after applying a weight of two hundred kilogrammes, whereas forty kilogrammes sufficed in the case of a woman eighty-two years old.

Fractures of the ribs occur very frequently, nevertheless, in consequence of their exposed position. Gurlt estimates that they constitute nearly sixteen per cent of all fractures, being only exceeded in frequency by those of the forearm, the leg, and the clavicle. Fractures of the ribs are more common among men, as they are more exposed to injuries, and in elderly individuals. They are very rare among children, on account of the above-mentioned extreme elasticity of their

ribs. According to Shaw, all persons with diseases of the heart and the blood-vessels have strikingly brittle ribs. He accounts in this way for the frequent fractures of the ribs among the insane. The middle ribs, being those most exposed, are chiefly subject to injury, especially the fourth to the eighth. The seventh is most frequently broken, and the first, second, and third least frequently, in consequence of their more protected location.

Fractures of the ribs occur from direct and from indirect violence. If a rib is broken by direct violence—e. g., by a kick or a blow—the fragments are forced inward and the pleura and thoracic organs may very easily be injured. In fractures from indirect violence—e. g., from compression of the thorax as a whole—the ribs are bent beyond the limit of their elasticity. In indirect fractures the danger of injury to the pleura and the thoracic organs is much less, as the fragments are bent not inward but outward. These indirect fractures occur most frequently in the middle of the bone, though they are also found in front of and behind the middle, and even at the neck of the rib and behind the angle. The location of the fracture depends very largely upon the direction in which the force is exerted. Several ribs are often broken, and not infrequently there is a fracture of the anterior and posterior portions of the same rib.

In rare cases fractures of the ribs are caused by violent muscular action—e. g., in severe coughing or sneezing, and also during labour. Generally speaking, fractures of the ribs from muscular action are only possible when their structure has lost in part its power of resistance in consequence of abnormal brittleness or softness—e. g., in old age, after a long and exhausting illness, or in consequence of osteomalacia, etc.

Fractures of the ribs are for the most part transverse or oblique. Partial or green-stick fractures are not uncommon. Simple comminuted fractures are comparatively rare. Compound fractures occur especially in connection with gunshot and stab wounds, and if the thorax is opened at the same time all the dangers of a penetrating injury of the thorax result. In connection with the subject of penetrating wounds of the thorax (§ 120) we shall take up these compound fractures of the ribs more in detail, and hence we shall not describe them more fully here. Sometimes, as was said above, there is only an internal wound, caused by laceration of the pleura by the fragments, especially in cases of direct fracture.

In all fractures of the ribs, the associated injuries, particularly those of the pleura, the lungs, and the heart, must be considered. If the parietal pleura is torn, which very frequently happens, a moderate hæmothorax usually ensues, especially if the visceral pleura and the

adjacent lung tissue are injured. In the latter case one often observes pneumothorax also in consequence of the passage of air through the tear in the lung into the pleural cavity. This pneumothorax is, however, slight in simple fractures of the ribs, because the rent in the lung quickly closes. A collection of air (emphysema) in the subcutaneous cellular tissue in the neighbourhood of the fracture may occur in simple fracture in case the lung has become adherent to the parietal pleura in the vicinity of the fracture. In consequence of injury to the lung a large extravasation of blood may take place into that organ, and inflammation and suppuration of the lung and pleura may ensue from microbic infection.

In rare cases fractures of the ribs are complicated by injuries to the pericardium, the heart, the diaphragm, and the abdominal viscera (liver, spleen, stomach, intestines). Finally, death has in some cases been observed in consequence of rupture of the intercostal vessels.

The principal symptom of fracture of a rib is pain at the point of injury, especially on taking a long breath, coughing, sneezing, or on pressure with the finger. It is also characteristic of fracture of a rib that this pain at the site of fracture is made worse by compressing the entire thorax in its transverse or sagittal diameter perpendicularly to the point of injury. Crepitus can often be felt if one lays the palm of the hand upon the painful spot and has the patient take a deep breath. Crepitus can often be heard, also, by placing a stethoscope over the site of injury or by direct auscultation with the ear. Symptoms of fracture other than pain and crepitus are usually absent in simple fractures of the ribs; and as crepitus can often not be made out, it is clear that fractures of the ribs may be easily overlooked, or that one may diagnose such a fracture when none exists. There is usually an external deformity only when several ribs are broken. Abnormal mobility is very deceptive and is usually of no value in making the diagnosis.

One should make sure by percussion and auscultation whether the lungs and pleura are injured; whether, for example, a hæmothorax or a pneumothorax is present. If a lung is seriously injured the sputum is usually bloody. Dry, pleuritic friction sounds are generally heard in the further course of every fracture of the ribs. Emphysema of the skin often occurs in connection with simple fracture of the ribs if, as was mentioned above, an adherent portion of lung near the site of fracture is injured.

The prognosis of a simple fracture of the ribs without complications is altogether favourable, and bony union always takes place. The outcome depends chiefly upon the accessory injuries. The wounds of the pleura and

lungs usually heal aseptically in subcutaneous injuries. The blood and air in the pleural cavity are gradually absorbed. Empyema and inflammation of the lungs may result, however, in cases of already existing disease of the lungs due to microbic infection—e. g., bronchitis, bronchiectasis, etc.

The treatment of fracture of the ribs consists in immobilization of the fragments as far as possible by fixation of that side of the chest, in order to hasten the union of the fracture and to relieve the pain. There is usually no displacement that requires reduction. It is better, at any rate, to let any existing displacement alone than, as has been proposed, to overcome it by operative measures, inasmuch as it generally disappears of itself. There exists only exceptionally any occasion for operative interference with the fracture as such—e. g., resection and suture of the fragments. The best method of immobilizing the fracture or the half of the thorax that is involved is by the use of India-rubber bandages about the thorax or of strips of adhesive plaster two or three fingers wide, which pass from the border of the sternum to the spine. These strips are applied from below upward, and in such a way that they half cover each other. It is not necessary to keep the patient in bed. On the contrary, he feels more comfortable in a sitting or upright posture. A little morphine may be given internally to overcome the tendency to cough. For the treatment of any complications that may exist on the part of the thoracic organs (pleura, lungs, blood-vessels, pericardium, heart) or the abdominal viscera (diaphragm, liver, stomach, intestines, etc.), the reader is referred to the injuries of these organs. In the case of old, decrepit persons the danger of hypostasis and œdema of the lungs should always be kept in mind. As a result of mal-union of a fracture, neuralgia of the intercostal nerves sometimes ensues, which can be overcome by operative removal of the abnormal callus, or by stretching or neurectomy of the intercostal nerve in question (see § 125, page 701).

Fractures of the costal cartilages occur most frequently in advanced age, when they have become more or less ossified. They are by no means so common among young persons. In the latter case fractures of the sixth, seventh, and eighth costal cartilages are the most common, especially near the junction of the costal cartilage with the rib proper. Transverse fractures are the most common. The causes, complications, and symptoms are essentially the same as in fractures of the ribs. A displacement of the fragments often takes place—e. g., one fragment is displaced laterally or longitudinally. If several cartilages are fractured and afterward unite with deformity, corresponding gutter-shaped depressions of the thorax remain permanently.

The treatment also is the same as for fracture of the ribs. The

repair of fractures of the cartilages is accomplished by the formation of a callus by the perichondrium which surrounds the two ends of the fragments. The fractured surfaces of the cartilage take no part in this process.

Dislocations of the Ribs.—Dislocations of the ribs are very rare. They arise probably in every case from the action of direct violence upon the articulation at the spinal column or the sternum (first to the seventh rib). Dislocations of the ribs are usually combined with other severe injuries, so that they themselves play only a subordinate part.

Dislocations of the ribs at their articulation with the spinal column are usually in a forward direction, and likewise in the dislocations or diastases at the costo-sternal articulation the cartilage is dislocated forward upon the sternum. Separation of the ribs from their connection with the costal cartilages is very rare. Its treatment is the same as that for fracture of the ribs. In most cases we have to do really with a fracture of the costal cartilage. Finally, diastases in a forward or backward direction have also been observed in the amphi-arthroses between the borders of the sixth to the tenth rib, which are in contact with each other. The lower cartilage is usually dislocated in front of the upper one. These amphi-arthroses exist, as is known, only in young persons.

The diagnosis of dislocation of the ribs from the bodies of the vertebræ can seldom be made with certainty, as the symptoms are almost identical with those attending fracture of the ribs. Reduction is impossible. The treatment is the same as that for fracture of the ribs. It aims at fixation of the head of the rib in its new position.

The diagnosis of a dislocation of the costal cartilages at the costo-sternal joint usually presents no difficulty, as there is generally a distinct prominence upon the anterior surface of the sternum. Reduction is secured by forced dorsal flexion of the trunk—e. g., over a roller cushion that has been placed beneath—and then by direct pressure upon the dislocated cartilage. In order to retain the cartilage in its proper position, its fixation by aseptic suture may be undertaken if necessary.

Permanent reduction of a dislocation between the edges of the sixth to the tenth cartilage is scarcely possible, as a rule, but the deformity that remains has no special importance.

§ 119. **Wounds of the Thorax.**—The wounds of the thorax are either pentrating—that is, such as go through the entire thickness of the thoracic wall and open the pleural cavity—or non-penetrating.

Non-penetrating wounds of the thorax are simple injuries, free from danger, which rapidly heal under antiseptic treatment. If not

treated aseptically and suppuration occurs, extensive burrowing of pus beneath the thoracic muscles may follow, and empyema, from transportation of pus microbes by means of the lymph passages, though there may be no continuous spread of the suppuration. Empyema sometimes follows an erysipelas that develops in connection with a non-penetrating wound of the thorax which has not received aseptic treatment.

The bony portions of the thorax are injured especially by gunshot and stab wounds. The course taken by the bullet is sometimes surprising. Rare cases have been observed in which round balls especially, less frequently long or pointed bullets, made a partial circuit of the thorax beneath the skin and came out at the opposite point or remained embedded there (contour shots). A distinction has been made between external and internal contour shots of the external or internal thoracic wall. König and Riedinger are no doubt right in their opinion that the occurrence of these contour shots has been greatly exaggerated and that they are based chiefly upon errors in observation. According to clinical observations and experiments by W. Koch, Klebs, and others, we know that a ball may pass through the thorax from in front backward without injury to the thoracic organs, and that nevertheless these are not contour shots. Non-penetrating gunshot wounds have, under antiseptic treatment, a thoroughly favourable course. The ball often heals in place, then travels downward sometimes, and makes its appearance in a different part of the body. Other foreign bodies, such as buttons, portions of the clothing, etc., are also frequently driven in with the ball, occasioning suppuration.

Injury to the blood-vessels, including the long thoracic, the internal mammary, and the intercostal arteries, is of special importance (see page 672).

Injuries to the bones (ribs, sternum, clavicle, scapula, spine) from gunshot wounds, for instance, may take the form of a slight grazing of the bone, or simple fractures, or the bone may be extensively splintered.

The treatment of non-penetrating wounds of the thorax conforms to general rules, and antiseptic precautions must be strictly observed (see Principles of Surgery). If, in gunshot wounds, the ball is found, it should be removed at once. Care must be taken in using the probe not to pierce the pleura. Other foreign bodies and completely separated splinters of bone are also to be removed. In case of burrowing of pus liberal incisions in the most dependent areas are imperative. One should look out especially for burrowing of pus beneath the scapula, which may be hard to detect. The treatment of compound frac-

tures is in accordance with the rules given in Principles of Surgery, page 597 ff. Their course, under antiseptic treatment, is very favourable.

Injury to the long thoracic artery is not so much to be feared as that of the internal mammary and the intercostal arteries. I once saw, in the case of a bleeder, dangerous hæmorrhage from the long thoracic artery. The vessel could not be found in the wound, and there was marked extravasation of blood. The hæmorrhage was arrested by a dressing that exerted pressure, and the already extremely anæmic patient was saved.

Injury and Ligation of the Internal Mammary and Intercostal Arteries.—The internal mammary artery arises, as is known, from the subclavian artery opposite the thyroid axis, descends at a distance of about one centimetre from the border of the sternum, in front of the costal pleura and the intrathoracic fascia, behind the ribs, and divides near the sixth costal cartilage into the musculo-phrenic and the superior epigastric arteries. The latter anastomoses with the inferior epigastric artery. Fatal hæmorrhage from the internal mammary artery has sometimes been seen, especially after it has been wounded by a stab or gunshot injury, and also after its erosion in consequence of suppurative inflammation of the breast (mastitis), as in a case reported by Pirogoff. In case of internal hæmorrhage into the mediastinum (hæmo-mediastinum) the correct diagnosis may be very difficult or impossible. The location of the injury, the increasing anæmia, and the symptoms of pressure within the thorax are important factors. Injury to the internal mammary artery is usually complicated by other injuries, especially those of the pleura and the pericardium, and this explains the high mortality, which reaches, according to Voss, sixty-eight per cent. The mortality attending injury of the artery alone is very much lower. Aneurisms sometimes develop after injuries of the internal mammary artery.

Ligation of the internal mammary artery in the wound is often impossible because its ends retract behind the ribs. In such cases the two overlying costal cartilages should be resected, or the vessel may be sought in the adjacent intercostal spaces above and below. Both ends of the artery must be tied, because otherwise, as has also been emphasized by Madelung and others, secondary hæmorrhage from the lower end may occur in consequence of the anastomosis with the inferior epigastric artery.

To find the internal mammary artery a transverse incision is made from the border of the sternum in the middle of an intercostal space parallel to the ribs (see Fig. 341). After dividing the skin, the pec-

toralis major, and the two intercostal muscles, the artery is seen lying with one or two veins in the connective tissue in front of the pleura.

Injury to the intercostal arteries may also occasion dangerous hæmorrhages. Serious hæmorrhages have likewise been caused by erosion of the arteries in caries of the ribs. In each intercostal space, as is known, there are two arteries, one near the superior and one near the inferior border of the rib. The one which passes along the inferior border of the rib in a groove on its posterior surface is the larger (posterior intercostal artery). The nerve lies below the artery and the vein in front of it. Injury to the anterior intercostal arteries is not dangerous. Injury to the posterior intercostal arteries near the spinal column is the most unfavourable. Of fifteen cases in the American civil war, eleven, according to Riedinger, proved fatal. If the pleura is opened, a hæmothorax results.

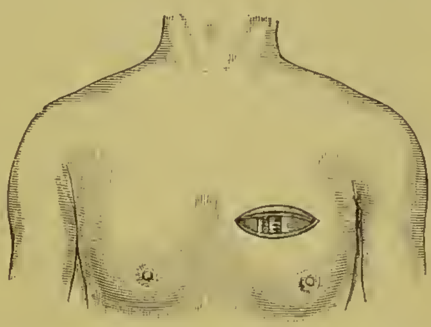


Fig. 341.—Ligation of the internal mammary artery.

The hæmorrhage from injury to the posterior intercostal arteries is best arrested by ligation of the artery in the wound both proximally and distally from the injury after elevating the periosteum and cutting away the border of the rib.

§ 120. **Penetrating Wounds of the Thorax.**—Penetrating wounds of the thorax—that is, those attended with opening of the pleural cavity—are always to be regarded as serious injuries, although at present, since the adoption of antiseptic methods in surgery, their prognosis has greatly improved.

In penetrating wounds of the thorax there come into consideration injuries to the pleura, the lungs, the pericardium, the heart, the anterior and posterior mediastinum, and the large blood-vessels. For injuries to the trachea, the œsophagus, and the spine the reader is referred to the corresponding paragraphs.

I. **Injuries to the Pleura** may affect only the parietal pleura or the visceral pleura also and the lungs. Injury to the pleura is most commonly caused by incised, punctured, and gunshot wounds, by severe crushing, with fracture of the ribs—e. g., from being buried up, from being run over, etc. In the case of punctured wounds, the point of the instrument that inflicts the wound (knife, dagger, bayonet, spear, etc.) may break off. In punctured wounds that are made in a direction perpendicular to the thorax, the lungs, heart, and large blood-vessels are more likely to be injured than when the wound is inflicted in an

oblique, tangential direction. In gunshot wounds the pleura is often opened, not by the ball, but secondarily, by the fragments and splinters of bone from the fractured ribs. As has been correctly stated by Arnold, Socin, and Riedinger, the wound closes over more quickly when there is simultaneous injury of the costal and visceral pleura than in cases of injury of the costal pleura alone. When the visceral pleura is injured the depth of the wound in the lung is of great prognostic importance.

The course of an opening into the pleural cavity depends partly upon the accessory injuries and partly upon whether the wound in the thorax remains open or closes immediately after the injury. In the former case, with open communication into the pleural cavity, the lung on the involved side is immediately compressed by the air forcing its way in from without, it collapses, ceases to perform its function, and a pneumothorax is the result.

In pneumothorax the circumference of that side of the chest is increased, the ribs are separated, the intercostal spaces bulge outward, and extreme dyspnœa is not infrequently present. There is tympanitic resonance and the breathing is absent or diminished. If fluid is present at the same time, succussion or splashing sounds are heard on shaking the patient, and, moreover, metallic tinkling. If, however, as is frequently the case, the lung is adherent to the chest wall or the diaphragm, it collapses only so much as the adhesions permit. It continues to perform its function so far as possible and the physical signs correspond to this.

Microbes enter the thorax with the air and here cause, under certain circumstances, inflammation and suppuration. An empyema or a pyothorax, and, in case both pus and air are present, a pyo-pneumothorax results and death may follow from compression of the lungs and the heart or from septicæmia and pyæmia, if the pus and the septic materials are not removed from the pleural cavity.

In consequence of the violence inflicted, foreign bodies are frequently found in the thorax—e. g., splinters of bone, broken knife or spear points, balls, shreds of clothing, etc. These also, being vehicles of infection, are frequently the cause of subsequent empyema.

In case of empyema of sufficient extent, the thorax bulges outward, the intercostal spaces are obliterated, the percussion note is flat, and the breathing is diminished or absent. The vocal fremitus is also diminished or absent. The heart is pushed more or less toward the sound side, according to the amount of the exudate. If the exudate is excessive and is not promptly removed by means of thoracotomy or aspiration, the action of the lung on the sound side also gradually becomes weaker and death ensues from paralysis of respiration.

The second category of wounds of the pleura includes those cases in which there is no open communication with the outside air—i. e., in which the wound is small and closes immediately after the injury. The course of the injury in such cases is variable, three different ones being distinguished: 1. There ensues no pneumothorax and no pleurisy; the injury runs a very favourable course, like one that is subcutaneous. 2. A pneumothorax results, but, as no microbes and no foreign bodies with microbes attached to them have entered the pleural cavity, no inflammation and suppuration ensue; the aseptic pneumothorax disappears by absorption and a complete return to the normal follows. 3. Microbes gain access to the pleural cavity at the moment of injury, either with the air or the foreign bodies, and, although the wound closes immediately, inflammation, suppuration, or sloughing is set up, depending upon the nature of the pathogenic organisms concerned.

A favourable course, without pneumothorax, is observed especially in wounds that are inflicted obliquely, so that the wound of the skin and that of the pleura do not correspond. Closure of the wound by means of the muscles is also important with reference to its course. As Socin has correctly stated, pneumothorax is more likely to occur after gunshot wounds through parts where the muscles are thin than is the case where there is a thicker layer of muscles.

In all cases in which the wound in the thorax has closed after the injury and no unfavourable symptoms exist, probing should not be attempted, as it is important that the closed wound should not be reopened.

We have already emphasized the fact that the course of a wound of the pleura is also very largely influenced by any accessory injuries that may exist, particularly those of the lungs, the heart, the large blood-vessels, and the diaphragm. If the latter is injured, the stomach, the intestine, the spleen, and the liver may enter the thoracic cavity through the rent thus made. Such a traumatic hernia of the diaphragm may exist for years even in a severe form without occasioning very great functional disturbances.

II. **Injuries of the Lungs.**—In injuries to the lungs from punctured, incised, and gunshot wounds the depth and the size of the wound are of the greatest importance. The course of a wound of the lungs depends, above all, upon the amount of hæmorrhage. If death follows immediately or soon after the reception of such an injury, the severe hæmorrhage that attends it, the hæmothorax, is usually the cause. The hæmorrhage is most severe after injury to the root of the lung. Superficial wounds of the lung are usually without significance, because the wound closes spontaneously in consequence of the elasticity of the lung tissue.

In gunshot wounds of the lungs, aside from mere grazing of the organ, there either exist blind wound canals, so that the ball remains in the lung, or the canal extends completely through the lung or the thorax, with an entrance and exit opening. The most severe injuries to the lungs arise from laceration and crushing of the organ from being run over or from large projectiles. Injuries to both lungs are always serious. They occur most commonly, aside from crushing caused by blunt violence, from punctures and gunshot wounds inflicted from the side, or from very obliquely inflicted injuries of the anterior and posterior walls of the thorax. In case of double pneumothorax and hæmothorax death usually takes place immediately. Pneumothorax in connection with injury to the lungs may arise partly from the outside through the wound in the pleura, and partly from within through the wound in the lung. Pneumothorax is most likely to arise from the latter cause in case a large bronchus has been opened. Such a pneumothorax arising from the wound in the lung is generally of little significance, as the latter usually closes in consequence of the elastic retraction of the lung tissue, and the smaller bronchi are obstructed by blood clots. Sometimes, however, pneumothorax arises from the wound in the lung later on if, for example, a bronchus is opened through suppuration of the pleura or the lung.

Very surprising recoveries have sometimes been observed after injuries to the lungs—e. g., after empalement of the thorax and the lungs upon stakes, or after gunshot or punctured wounds. Longmore reported the case of a soldier who received a puncture from a spear through the right side of the chest so that the point projected at the back. The spear was broken in two and the point was removed with difficulty from the posterior wound and the rest of the spear from the anterior wound. Nevertheless, recovery took place, with full return of function. Riedinger, in his treatise upon injuries of the thorax (Die deutsche Chirurgie, Lief 42), has reported several surprising cases of recovery.

Aside from the extent of the injury, the amount of hæmorrhage, and possible accessory injuries—e. g., of the heart, the large blood-vessels, the œsophagus, the diaphragm, and the abdominal organs—the entrance or non-entrance of pathogenic micro-organisms into the lungs or into the pleural cavity has a decisive influence upon the course of an injury to the lungs. Any foreign bodies, therefore, that may have entered with microbes adhering to them play an important part here. If the foreign bodies are free from microbes, they may become encapsulated in the lung, just as elsewhere (see also page 678).

The symptoms of injuries to the lungs are very variable. It is not

infrequently observed that even after severe injuries to the lungs the patient is comparatively comfortable. The symptoms are sometimes so slight that a diagnosis is scarcely possible during life. In the first moments after the infliction of the wound its extent and the amount of hæmorrhage determine the course, but the latter depends later upon whether or not the wound remains aseptic. If it is aseptic, and no inflammation or suppuration ensues in consequence of infection with pyogenic micro-organisms, healing follows without reaction.

Among the symptoms of injury to the lungs, the expectoration of a bloody, frothy material for a longer or shorter period, and varying in amount, is very important. A cough with the raising of blood, and later of mucus and pus, is often present. Occasionally small foreign bodies are coughed out.

The amount of dyspnœa depends chiefly upon the extent of the injury to the lung, the presence of a hæmothorax or pneumothorax, and later on of inflammation of the lungs and the pleura, with effusion into the pleural cavity. Hæmothorax is present in greater or less degree, according to Riedinger, in three quarters of all cases of injury to the lungs. The same physical signs are present as in pleurisy with effusion which we have already briefly mentioned (page 674). Prolapse of the lung through the external wound is rarely observed. It usually disappears again gradually, and gangrene rarely follows.

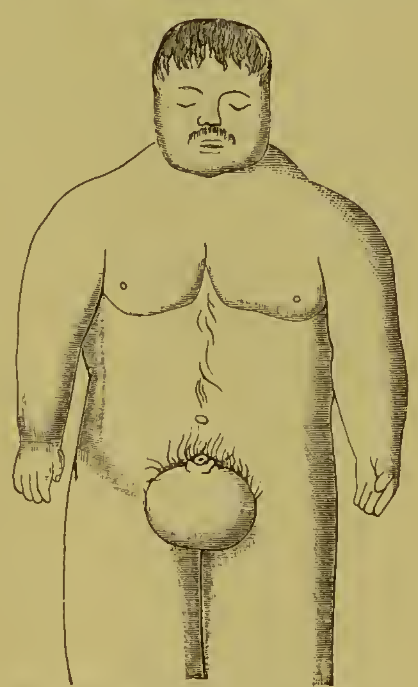


Fig. 342.—Emphysema of the cutaneous covering following a punctured wound in the right axilla made with a rapier.

Emphysema, or a collection of air in the neighbourhood of the wound, which may spread still farther within the subcutaneous cellular tissue, is a very important symptom, and is always an indication of injury to the lung. This emphysema of the skin is usually absent, however, when an open communication exists between the interior of the thorax and the external air, so that the latter can enter and pass out from the thorax without hindrance. On the other hand, when the wound has an oblique course, or when the external opening has closed and the injured lung become adherent to the costal pleura, the subcutaneous emphysema may extend over the body very quickly, as, for example, in the case shown in Fig. 342. In this case, which was observed by

Larrey, the famous field surgeon of the first Napoleon, the subcutaneous emphysema, consequent upon puncture from a rapier in the right axilla, had assumed this enormous extent within six hours. Death from suffocation may ensue in such cases, especially when an emphysema in the connective tissue of the mediastinum increases to any great extent. Riedinger mentions a case observed by Hall, in which emphysema of the entire covering of the body developed in two days, and still the patient was in a condition to go about again after eighteen days.

The symptoms of wounds of the lung in their later course vary according to the development or non-development of inflammation and suppuration within the pleural cavity (empyema, pyothorax) and the lungs (infiltrations, abscess, gangrene) from the entrance of microbes by themselves or attached to foreign bodies. An empyema may perforate externally into the lungs, into the large blood-vessels of the thorax, or through the diaphragm as a subphrenic abscess into the intestine, the stomach, etc. The same is true of lung abscesses. If an abscess of the lung opens into a bronchus, large amounts of pus are suddenly discharged through the mouth, and the same is true if a suppurative process in a lung or the pleural cavity ruptures into the stomach or intestine. Sometimes after a lung abscess breaks through externally, a permanent fistula of the bronchus or the lung results. I recently saw two cases of the kind in which a fistula remained after an abscess of the lung had broken through the diaphragm and the skin of the back beneath the free border of the ribs.

The termination even of a serious injury to the lungs, as was said above, may be complete recovery without appreciable functional disturbances. In other cases permanent disturbances remain—e. g., in consequence of pneumonia, lung abscess, empyema, etc. These disturbances are chiefly impeded respiration, resulting from contraction of the lungs, chronic inflammations of the bronchi and the lungs (fibroid phthisis), emphysema, adhesions, etc., accompanied not infrequently by asymmetry of the thorax and scoliosis of the spinal column (see Deformities of the Spine). Death follows either in consequence of the severity of the injury, especially from internal hæmorrhage and complicating accessory injuries—e. g., of the heart, the large blood-vessels, the œsophagus, the spine, the diaphragm, and the abdominal organs, or in consequence of septic processes, especially pyo-pneumothorax, abscess of the lung, gangrene of the lung, etc. Foreign bodies remaining in the lung may, if they are free from microbes, become encapsulated without causing any reaction. Cases have been observed in which balls, shreds of clothing, splinters of bone, sabre points, buttons, etc., remained in the lungs for years, and were only discovered by acci-

dent at the autopsy. Generally speaking, however, all foreign bodies located in the lungs always remain a source of danger, as is proved by numerous observations—e. g., by Lossen, H. Fischer, Demme, Socin, and others—as they may later on produce circumscribed or diffuse suppurative inflammations of the lungs and the pleural cavity, and thereby cause death more or less suddenly, even after the lapse of years (see also § 104, page 610).

Regarding disturbances due to accessory injuries to other organs of the thorax, to the diaphragm, and to the abdominal organs, the reader is referred to the corresponding injuries. It need only be added that not infrequently injury to the phrenic nerve causes vomiting and pain in the diaphragm, or paralysis of the half of the diaphragm that is affected. Permanent paralysis of the pectoralis major may follow injury to the anterior thoracic nerve. Injuries of the intercostal nerves not infrequently induce intercostal neuralgia, and the latter, as has been mentioned, may also be caused by fractures of the ribs which have united with deformity.

Slessehanowsky, Sklifassowky, H. Hadlieh, and others have given careful study to the microscopic processes that attend the repair of wounds in the lungs and pleura. H. Hadlieh investigated the healing proeess in simple punctures and incised wounds of the lungs and pleura in dogs and rabbits. The wounds had never caused a pneumothorax and they healed without other complieations. Not a few of the rabbits died immediately after the injury in consequenee of hæmorrhage. There oceurred at first in connection with the injury to the lung a more or less extensive infiltration of the tissues with blood due to the anatomical structure of the lungs and the aspiration of blood through the bronchi. The wound in the pleura closes in eonsequence very quickly. Of the subsequent processes, the desquamation of the alveolar epithelial cells is next to be mentioned, whieh are found as large more or less opaque cells with a large round nueleus both in those alveoli containing blood and in those free from blood. The infiltration of the connective-tissue reticulum of the lungs and pleura with round eells is also noticeable. These are especially numerous in the lymph spaces and in the walls of the arteries, being so dense in the smaller ones that the lumen of the artery becomes completely closed. The eicatrices often reveal a system of cavities, which individually are ten or more times as large as the normal pulmonary vesicles. They are separated by partition walls, which are in part complete and in part incomplete ; they are lined with epithelium, are filled with air, and communicate with the bronchi. Obliteration of the lumen of the bronehi was not observed on cross-seetion.

Generally speaking, the same proeesses manifest themselves in the healing of wounds of the lung and pleura as in those of other organs and of the serous membranes. The cicatrix is formed mainly from the endothelial cells of the capillaries, vessel sheaths, lymph spaces, etc. Here also healing ensues either by primary or secondary union. Extensive adhesions are usually formed between the visceral and the costal pleura.

The diagnosis of an injury to the lung is made from the above-described symptomatology. It is frequently, however, not easy, inasmuch as there may be very insignificant symptoms in spite of actual injury of the lung. The most important symptoms indicating injury to the lung are hæmoptysis, the escape of air and blood from the thoracic wound, pneumothorax, and emphysema of the external wound. The latter is often absent. The position and direction of the wound are also important. One must always make a careful physical examination of the chest by percussion and auscultation, but during the examination all undue movement of the patient is to be avoided. The use of the probe for the purpose of confirming the diagnosis is not permissible. The macroscopic and microscopic examination of the sputum, in which shreds of cloth or other foreign bodies have been found, may be of great value.

The prognosis of injuries to the lungs has been sufficiently discussed above. Riedinger estimates the mortality from these injuries at about sixty per cent. The statistics which we now possess upon this subject, however, show very varying results and are, generally speaking, of little value. The prognosis of these injuries has become very much better in consequence of the adoption of antiseptic methods in treating wounds; and the earlier a wound in the lung is treated antiseptically, the more confidently may a favourable course be expected. Death follows injury to the lungs either, as has been said, soon after the reception of the wound, in consequence of its severity, particularly from hæmorrhage, or later, in consequence of inflammation and suppuration resulting from infection of the wound by pyogenic micro-organisms.

Treatment of Penetrating Wounds of the Thorax.—We will here summarize the treatment of the wounds of the pleura and lungs that have thus far been spoken of.

Every penetrating wound of the thorax, like any other wound, should receive antiseptic treatment in accordance with the generally accepted rules for dealing with wounds, such as we have described them more in detail in our treastise upon the principles of surgery. The earlier a penetrating injury to the thorax receives antiseptic treatment the better.

The first thing in dealing with these wounds, as with all others, is to arrest the hæmorrhage, which arises in part from the vessels of the thorax (long thoracic artery, intercostal arteries, internal mammary and subclavian arteries) and in part from the lungs. Hæmorrhage from the lungs is, generally speaking, either moderate or so extreme that nothing can be done. We are, as a rule, practically powerless in dealing with hæmorrhage from the lungs. In suitable cases the effort should be made, if the hæmorrhage is severe, to arrest it by opening the thorax and exposing the wound, and then, if it is accessible, applying a catgut ligature or taking a deep suture.

Regarding the treatment proper of penetrating thoracic injuries, we may distinguish two principal classes of cases: (1) Those injuries in

which the wound has closed again, and (2) those in which there remains an open communication between the pleural cavity and the external air.

In cases of the first class, in which the wound has closed again and no open communication exists between the pleural cavity and the outside air, and no threatening symptoms of hæmothorax or hæmo-pneumothorax are present, the external wound in the chest and the surrounding parts should be disinfected with 1-to-1,000 bichloride, etc. The wound should not be sutured but covered with iodoform gauze and with a thick antiseptic, protective dressing which includes the chest, the shoulders, and the upper part of the abdomen. The patient must remain in bed and be kept as quiet as possible. The symptoms on the part of the thoracic viscera, the pulse, and the temperature should be carefully observed. In this way healing may ensue without reaction or any further disturbance. If there is fever or dyspnœa, or if the physical examination reveals a large exudation in the pleural cavity, it may be necessary to open the cavity by puncture (thoracocentesis) or by incision (thoracotomy), which is best combined with resection of one or more ribs. In such cases one should at first make an exploratory puncture with an aspirating needle which has been carefully sterilized by being heated red hot over an alcohol lamp and afterward put in five-per-cent carbolic acid, and then perform thoracocentesis or thoracotomy, according to what the condition is found to be. In case of serous effusions in the pleural cavity and in hæmothorax, simple aspiration (Principles of Surgery, page 70) should be performed, while in case of suppurative effusions, thoracotomy, with resection of one or more ribs in order to insure proper drainage, is to be preferred, especially if there is sloughing of the pleura. For the technique of thoracocentesis and thoracotomy the reader is referred to § 126.

If we have to do with a penetrating thoracic wound of the second class—that is, if there is open communication between the thorax and the outer air resulting in a pneumothorax or a pneumo-hæmothorax, or if a pyo-pneumothorax is already present—the pleural cavity should, after enlargement of the wound, if necessary, and resection of one or more ribs, be carefully irrigated and disinfected with a three-per-cent solution of boric acid, one-third-of-one-per-cent solution of salicylic acid, two-per-cent solution of chloride of zinc, one-fifth-of-one-per-cent permanganate of potash, or sterilized one-per-cent solution of common salt, then drained and an aseptic dressing applied. The drainage should always be at the deepest part of the thorax, and it is therefore better to make a counter-opening on the posterior surface of the same between the eighth and ninth ribs, and here insert a short, stout drainage-tube

which is secured by means of a safety pin. During the irrigation of the thorax, of which I make use only in exceptional cases, the patient should assume different positions. He is to sit up, turned to one side, or lifted up by the legs, in order that the entire thoracic cavity may be thoroughly disinfected. Solutions of bichloride and carbolic acid should not be used in irrigating the thorax, on account of the danger of poisoning, and yet I have used without injury in cases of septic empyema solutions of 1-to-5,000 to 10,000 bichloride. One must, however, be very careful to see that the solution is completely removed again from the thorax. The antiseptic protective dressing must here also include the shoulders and abdomen and thoroughly shut out the thoracic wound from contact with the air. Later on the dressings are changed, particularly when they become saturated with the secretion or if the temperature rises (see the After-treatment of Thoracotomy, page 707).

The remainder of the treatment of wounds of the pleura and lungs is symptomatic. For hæmoptysis absolute quiet and the application of ice poultices to the chest are to be recommended. If there is extensive emphysema of the skin, one may, if necessary, provide an outward escape for the air in various places by making, under antiseptic precaution, small punctures with a needle or sharp-pointed bistoury. Morphine, either hypodermically or internally, can not, as a rule, be dispensed with. Any complicating diseases of the lungs in the later course are treated in accordance with general rules (see § 128, page 712, Surgical Treatment of Abscesses of the Lungs).

§ 121. **Injuries of the Pericardium and the Heart** occur by far the most frequently from without. They are comparatively rare from within, and both are usually injured simultaneously.

Injury to the pericardium alone is most commonly the result of perforations of its lower half in an oblique direction, especially in the case of an effusion within it. H. Fischer has collected from literature fifty-one cases of isolated injury to the pericardium from punctures, incised wounds, gunshot wounds, and blunt violence. These wounds, when free from complications, heal, according to Riedinger, in more than thirty per cent of the cases. The complications are chiefly injuries of the heart, the lungs, the large vessels of the thorax, and especially of the coronary arteries. The diagnosis of an injury of the pericardium is certain if the presence of blood or air within it can be made out —that is, in case of hæmopericardium or pneumopericardium. If pneumothorax and hæmothorax are present from simultaneous injury to the pleura and the lungs, the injury to the pericardium may be easily overlooked.

If no exciters of inflammation in the shape of pyogenic micro-organisms have made their way through the wound into the pericardium, the reaction may be very slight. There is a mild pericarditis and pleurisy, and complete healing follows without special disturbance, there being usually an adhesion of the pericardium to the heart. If microbes enter the pericardium, the result may be suppurative pericarditis and pleurisy with a fatal termination. If death ensues soon after the injury, it is usually due to other severe injuries—e. g., of the heart or the large vessels, the immediate cause being hæmorrhage, which is in part external and in part internal, into the pleura and the pericardium. In case of hæmopericardium—e. g., in consequence of injury to a coronary artery —death ensues from paralysis of the heart if the blood collected in the pericardium reaches such an amount as, by pressure, to prevent diastole of the heart.

Wounds of the heart are much more frequently penetrating than superficial—that is, they involve the entire thickness of the cardiac wall. Superficial wounds sometimes occur, to be sure, and nothing is known of them during life. According to H. Fischer, of three hundred and fifty-one wounds of the heart, only thirty-four were non-penetrating. Injuries to the heart occur especially from punctured, incised, and gunshot wounds, from splintering of the ribs and from crushing in consequence of the action of blunt force with rupture of the cardiac muscle. Injuries of the heart occur, as a rule, from without, and the right ventricle, which lies farther forward, is most frequently involved. Injuries of the heart may occur from within—e. g., from a swallowed needle which gets into the circulation and sticks fast in the heart. Ruptures of the heart usually result from being run over, from being crushed by the buffers of two railroad cars, and also from a fall from a height. By the action of extreme violence of this sort the heart may be completely detached or torn away. Rupture of the heart is sometimes favoured by the presence of fibrous myocarditis or parenchymatous degeneration of the cardiac muscle. In the latter case, rupture of the heart may occur spontaneously without any traumatism. Injuries of the heart have been observed, in connection with gunshot wounds, in which the pericardium was intact inasmuch as the spent ball had driven the elastic pericardium before it and still had inflicted a wound in the heart. Isolated injuries of the endocardium and the valves, especially the aortic and mitral valves, also occur—e. g., from a fall or from a contusion of the thorax, while there is no apparent injury either of the heart or the pericardium.

Wounds of the heart have in exceptional cases been known to heal when one would have supposed it impossible. In Riedinger's work

upon injuries of the thorax several examples of such cases are given. Brugnoli, for example, observed healing after a punctured wound of the heart. The man in question died nineteen years and seven months after the injury. The autopsy showed eccentric hypertrophy of the heart, with thickening and adhesions of the pericardium. In the wall of the right ventricle was found a cicatrix three centimetres long, likewise in the septum ventriculorum and in the mitral valve. There was open communication between the right and left side of the heart, which had caused during life loud systolic murmurs and bruits. Conner (Cincinnati) observed a gunshot wound through the left and right ventricles in which the ball made its exit through the right auricle. The patient lived for thirty-eight months after the injury. Kiawkoff found at an autopsy a puncture in the wall of the left ventricle that had begun to heal. The wound had been reopened six days after the injury was received in consequence of lifting a heavy load, and the patient fell dead. Death may occur from dilatation of the cicatrix and rupture of the heart due to a temporary increase in its activity, in consequence of external influences, even after healing has occurred (Martinotti). It has been proved, according to Kiawkoff, that at least seven per cent of the wounds of the heart have healed. This healing is accomplished by the formation of a cicatrix from the intermuscular and subepicardial connective tissue (Bonome).

The symptoms of a wound of the heart seldom come under clinical observation, for the reason that death, as a rule, follows immediately. The condition of the patient may be at first very good, because the wound in the heart is closed by a thrombus. Then death from hæmorrhage occurs suddenly when the shock is over, the patient has recovered from his fainting condition, and the heart's action has become stronger. The symptoms of wounds of the heart are essentially those of shock and internal hæmorrhage. The injured person sometimes falls dead at once, and in other cases he faints or may remain fully conscious. There generally exists a marked feeling of anxiety, the face is pale, the pulse weak, and the heart's action is scarcely felt if at all. Percussion and auscultation of the heart yield the most important results. If there is serious internal hæmorrhage one finds a rapidly spreading dulness due to the hæmopericardium, while in pneumopericardium the cardiac dulness is absent. By auscultation the cardiac sounds are found to be either faintly audible or altogether inaudible. The greatest variety of sounds has been described—e. g., splashing sounds, blowing sounds, or a metallic tinkle. In the later course symptoms of hæmopericardium, especially cyanosis and cardiac weakness, become prominent, or symptoms of inflammatory reaction, of serous

or suppurative pericarditis. One's attention is sometimes first drawn by the latter to the injury of the heart that has taken place.

Foreign bodies may become encapsulated in the heart and in the pericardium. Small balls and pins have been accidentally found at the autopsy ten, twenty, or thirty years after the injury. The foreign bodies lay in the pericardium, in the cardiac muscle, or in the ventricles. H. Fischer has collected from literature forty-seven cases of foreign bodies in the pericardium and the heart. The bodies had entered partly from without and partly from within, especially from the œsophagus. Only in rare cases did death immediately follow the injury.

If healing takes place after injury to the heart, there remain, as a rule, various disturbances—e. g., dilatation of the heart, weakness of the cardiac muscle, shortening and thickening of the valves, atheromatous processes, etc. The healing of an injury to the heart is comparatively slow. At first the wound is occluded by fibrin, and then heals gradually by the formation of a cicatrix, like the wounds in other striated muscles (see Principles of Surgery, pages 280–300, and 468). The blood in the pericardium is gradually absorbed, and any air that has entered likewise disappears. The pericardium and the heart usually become adherent to a greater or less extent in consequence of dry pericarditis.

Death follows penetrating wounds of the heart from hæmorrhage into the pericardium or the pleural cavity, or from external hæmorrhage. If the wound in the pericardium is small, the blood may collect rapidly in the latter, and by its pressure cause paralysis of the heart. In cases of rupture of the heart, death usually follows immediately. As is shown by Knoll's experiments, cessation of the heart's action can not result from pneumopericardium—i. e., inflation of the pericardium with air—as it does from hæmopericardium, because during the diastole of the heart the air is pressed into the tissues.

The prognosis of wounds of the heart is unfavourable, According to Kiawkoff and H. Fischer, recovery has ensued in from seven to ten per cent of the cases. The prognosis of rupture of the heart is least favourable, as death usually ensues immediately, or in exceptional cases after a few days. The prognosis of rupture of the valves of the heart is also unfavourable. According to Rose and Riedinger, of thirty-five such cases, twenty-four proved fatal. Oblique wounds of the heart seem to be more favourable. as they are more likely to heal spontaneously. The same is true of wounds of the apex of the heart, because here the muscle is thicker than that of the auricles, for example, wounds of which are very likely to be fatal. Injuries of the coronary arteries also have a very bad prognosis in consequence of the resulting hæmorrhage.

Points of special importance for the diagnosis of injuries of the heart are the location of the wound in the chest, the presence of hæmopericardium or pneumopericardium, murmurs from the valves and the pericardium, dyspnœa and diminution of the strength of the pulse in consequence of compression of the heart from hæmopericardium, and, above all, intact lungs and no hæmothorax. An injury to the heart, even one that is penetrating, often remains unrecognised during life, or attention is first called to it by subsequent suppurative pericarditis.

The treatment of injuries of the pericardium and the heart is, generally speaking, symptomatic; but since the adoption of antiseptic methods in surgery, a more active treatment is properly made use of. Here also probing should be avoided as far as possible. If the internal mammary or the intercostal arteries are injured, hæmorrhage from these is arrested by ligation (see pages 672, 673). We are powerless against severe hæmorrhage from the heart. Unfortunately, cardiac wounds can not be closed by suture. Any foreign bodies that may be present are, if possible, removed. The external wound, and, if necessary, that of the pericardium also, is disinfected according to general rules, drained if necessary, and covered with an antiseptic protective dressing. This is changed upon the appearance of fever, dyspnœa, or pain. Absolute quiet is of the greatest importance for the patient, and hypodermic injections of morphine can scarcely be dispensed with. The diet should be light and not exciting. Wine or whisky must be strictly forbidden. In case of collapse, stimulants, particularly camphor and ether, injected hypodermically, are indicated. Venesection was formerly recommended very generally for cardiac wounds in order to diminish the action of the heart and to restrict the hæmorrhage. Riedinger also is of the opinion that bloodletting ought not to be abandoned entirely in these cases. As a matter of fact, hæmorrhage from the wound in the heart has been very much diminished or wholly arrested by venesection.

When blood has collected in the pericardium (hæmopericardium), causing cyanosis or cardiac weakness, puncture or incision of the pericardium is to be recommended, likewise when there is marked serous or suppurative effusion in the same. In such cases a trial puncture with an aspirating needle should first be made, and if this reveals the presence of pus the incision is to be made in the middle of the area of heart dulness, usually in the fourth intercostal space. After the incision of the pericardium in case of suppurative pericarditis, the same should be drained. If the trial puncture reveals blood or serum—that is, hæmopericardium or serous effusion—the contents of the pericardium should be evacuated by puncture. This has been especially recommended by Rose in case of hæmopericardium with compression of the

heart. But in very large effusions of blood, incision might often prove more effective than puncture.

For the technique of puncture and incision of the pericardium the reader is referred to § 127, page 710.

§ 122. **Injuries of the Large Blood-Vessels in the Thorax.**—Injury to the large blood-vessels in the thorax is most commonly caused by punctured and gunshot wounds, and, moreover, from within the œsophagus by foreign bodies that have been swallowed—e. g., sharp, pointed pieces of bone, fish bones, and needles. Spontaneous rupture of the aorta, consequent upon a degenerated condition of its wall, has also been observed. The large vessels have sometimes been eroded in consequence of suppuration.

Wounds of the aorta, the superior vena cava, and the pulmonary artery almost always cause immediate death, in consequence of the enormous hæmorrhage. The fatal result is delayed only in case of insignificant injuries, such as small punctures or grazing gunshot wounds, with eschar formation. It is claimed that in rare cases small punctures of the aorta have been seen to heal. Hæmorrhage is sometimes arrested by the formation of a so-called traumatic aneurism. Temporary improvement follows until death ensues from rupture of the aneurism, which has gone on increasing in size. Injuries in which the large vessels of the thorax are not completely opened are the most favourable, the possibility of healing taking place being then greater. If, in consequence of pathological processes, or as the result of a traumatism, only the intima and media are ruptured, which occurs most frequently on the aorta, a so-called dissecting aneurism is formed—that is, the blood burrows a way for itself between the adventitia and the media. The adventitia is then sometimes separated from the media throughout the entire length of the aorta, it may be, and on all the large vessels to the point where the latter enter organs or are inclosed on all sides by unyielding tissue. Smaller rents in the intima and media may heal completely.

Treatment of the injuries and wounds of the large blood-vessels of the thorax, the aorta, the pulmonary artery, and the superior vena cava is not possible. For the ligation of the innominate artery, see Surgery of the Neck, page 518 ; for the ligation of the aorta, see § 157, Surgery of the Abdomen. W. Heineke has ligated the innominate vein successfully. Suture of the arteries and veins, as well as packing the wound with sterilized iodoform gauze, might be undertaken in suitable cases of injury of the large thoracic vessels.

§ 123. **Injuries and Diseases of the Thoracic Duct.**—The thoracic duct arises, on a level with the first and second lumbar vertebræ, to the left of the

aorta, and between the vertebral portions of the diaphragm, from the union of the two lumbar lymphatic trunks and a middle intestinal lymphatic trunk which usually empties into the left lumbar lymphatic trunk. The lymphatics of the intestine, the spleen, the pancreas, and a portion of the liver empty into the intestinal lymphatic trunk. The right and left lumbar lymphatic trunks are formed by the lymphatics of the lower extremities, the abdominal wall, the pelvis, and the laterally situated abdominal viscera.

In the thoracic cavity the duct lies at first between the aorta and the vena azygos major; from the sixth dorsal vertebra on it passes more to the left, and in front of about the third dorsal vertebra it goes behind the end of the arch of the aorta, and farther on behind the left subclavian artery, and then passes between the left carotid and the left subclavian arteries in a downward curve to its point of entrance into the angle made by the union of the left subclavian vein and the left internal jugular vein, or into one of these veins or into the innominate vein. Shortly before its termination it receives the lymph vessels of the left upper extremity and of the left half of the head. The circumference of the thoracic duct is given as from two and four tenths to three and six tenths millimetres. Many variations occur in its course. The trunk often divides repeatedly, and it frequently consists of a convolution of larger and smaller lymph vessels. According to Teichmann, it is the rule that the thoracic duct is made up in the thorax of two trunks which lie each to one side of the aorta and have the same course as the vena azygos major and minor.

The right common lymphatic trunk is, according to Henle, a vessel scarcely fifteen millimetres long and about two and four tenths millimetres in diameter, which is formed by the union of a jugular, a subclavian, and a bronchomediastinal trunk and carries the lymph of the right upper extremity, the right half of the head, the right half of the thyroid gland, the heart, the diaphragm, the anterior thoracic wall, and a part of the right lung to the angle formed by the union of the right internal jugular and subclavian veins. The trunk is often wanting, according to Henle, as the branches which should form it empty singly into the veins.

Injuries of the thoracic duct are usually of little surgical significance. They are generally combined with other and severe injuries of the thoracic viscera, so that, in comparison with the latter, they are of minor importance. In consequence of rupture of the thoracic duct a chylous hydrothorax results. Injuries of the thoracic duct usually cause no serious disturbances in man, aside from the temporary chylous hydrothorax, which is usually slight. In animals also ligation of the duct occasions no appreciable functional disturbances, in consequence of the collateral circulation, but death may ensue, according to Boegehold, in consequence of its rupture in animals, from inanition, and from compression of the lungs and heart by the great accumulation of lymph in the thorax. Slight injuries of the thoracic duct heal spontaneously by closure of the wound, since the pressure in the duct is negative. A collateral circulation is easily established after the obliteration of the

thoracic duct in man, since, as we saw above, there is usually more than one main trunk.

Treatment of rupture of the thoracic duct only comes into consideration when there is a large collection of lymph and chyle in the thorax, and symptoms of compression of the lungs and the heart appear. In such cases aspiration of the thorax is indicated.

The diseases of the thoracic duct are probably always of a secondary nature, and are then most commonly conditioned upon tubercular processes or upon malignant tumours, whose germs are transported through the lymph passages into the thoracic duct, where, under favourable circumstances, they may logde and develop in the wall or in a valve. The formation of concretions in the duct has also been observed in consequence of inspissation and calcification of the lymph.

§ 124. **Injuries and Diseases of the Diaphragm.**—*Anatomical Remarks.*—With reference to injuries and inflammatory perforations of the diaphragm—e. g., from an empyema, from a fæcal abscess in the abdominal cavity, from an ulcer of the stomach and intestines, etc.—it is important to remember that there are places of some size in the diaphragm, lying between the muscular portions, which are very thin and consist only of pleura and peritonæum. These thin, transparent, intermuscular spaces have as yet received little or no attention from a clinical standpoint. In my work upon the communications of the stomach and intestinal canal with the thoracic cavity and upon subphrenic fæcal abscesses (see Langenbeck's Archiv für klinische Chirurgie, Band xxvii, Heft 1) I have described these muscular interspaces of the diaphragm more in detail, and have shown that they are of considerable importance in injuries and diseases of the same.

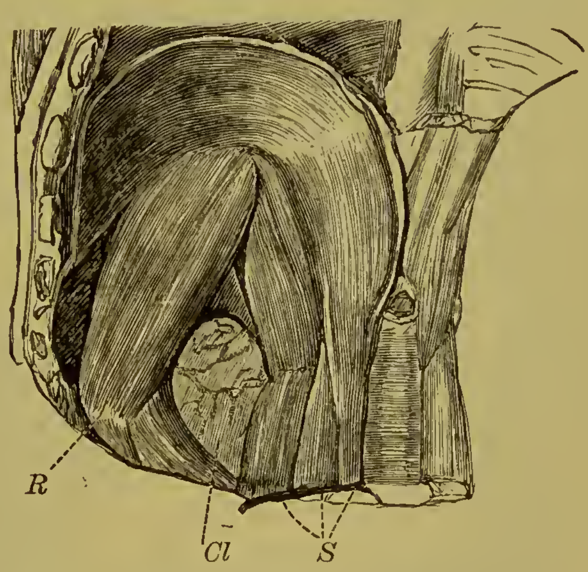


Fig. 343.—Muscular cleft (*Cl*) between the origin of the diaphragm from the spine (*S*) and from the ribs (*R*).

In the first place, there is an interval of some size between the origin of the diaphragm on the spine and the ribs. As I was able to determine from a large number of specimens, the size and form of these interspaces are very variable (see Figs. 343, 344, 345). The space often has the form represented in Figs. 343 and 344, or there may be two large spaces as in Fig. 345. There are also not infrequently on the right or the left, or even on both sides, three large spaces separated by muscular bundles, which consist of peritonæum and pleura with but little connective tissue. I also frequently found that the

entire lower part of the diaphragm was strikingly thin, while its muscular character only became prominent higher up.

This muscular interspace between the costal and spinal origins of the diaphragm is more or less covered by the kidney and the liver or by the connective tissue that envelops the kidney. The space is of especial importance in connection with the origin of rents and herniæ of the diaphragm and with the breaking through of pus from the thoracic cavity into the abdominal cavity, or, conversely, of abscesses of the kidneys, liver or spleen, subphrenic fæcal abscesses, etc., into the thoracic cavity. As Curschmann also has stated, empyemata make their way directly through this space, and may then spread farther between the peritonæum and dorsal muscles and come to the surface on the back.

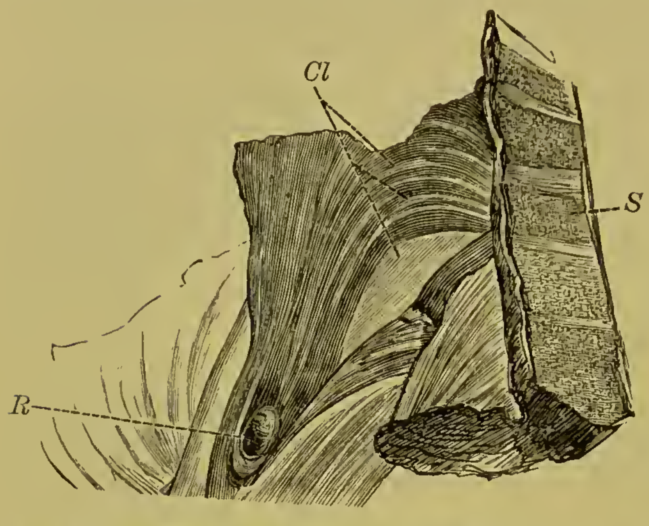


Fig. 344.—Muscular cleft (*Cl*) between the origin of the diaphragm from the spine (*S*) and from the ribs (*R*).

Between the costal and sternal portions of the diaphragm there is also a gap, triangular in form, with its apex directed upward, which is likewise of importance from a clinical standpoint. This also varies in size on the two sides. The gap lies between the muscular bundles which arise from the cartilages of the sixth and seventh ribs and from the sternum or its ensiform process. This space is covered on the right side by the pleura, but not upon the left side, so that paracentesis of the pericardium can be performed here between the fifth and sixth ribs close to the border of the sternum without injury to the pleura. The muscular fibres arising from the ensiform process are sometimes wanting, and in this case the gaps upon the two sides unite so that there is one large space, through which a diaphragmatic hernia may gain entrance to the anterior mediastinum (Cruveilhier, Luschka, Fothergill, Goblet).

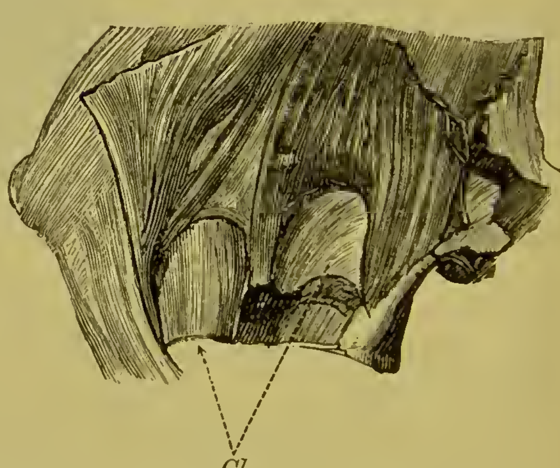


Fig. 345.—Two muscular clefts (*Cl*) between the costal and vertebral origins of the diaphragm.

Of the remaining openings of the diaphragm (œsophageal, aortic, for the vena cava, for the splanchnic nerves, for the vena azygos minor, and for the

sympathetic nerve), the œsophageal is the most important, particularly with reference to the origin of diaphragmatic herniæ. All the openings in the diaphragm that have been mentioned are sometimes abnormally large (Henle).

Aside from the spaces or gaps that have been alluded to, it happens occasionally that the muscular portion of the diaphragm is extremely thin. Marsh reported a case in which the left half of the diaphragm was almost void of muscular fibres, and this thin, lax half of the diaphragm was arched upward as far as the third intercostal space, so that the stomach lay in the thorax. The right half of the diaphragm was normal. The power of resistance of the diaphragm may also be greatly lessened by fatty degeneration of the same.

Injuries of the diaphragm are not uncommon. They are either subcutaneous (e. g., in consequence of a fall, a blow, or crushing of the thorax and the abdomen) or open wounds (e. g., from punctures or gunshot injuries). Subcutaneous ruptures of the diaphragm occur most frequently from a fall or from being run over, less often in consequence of severe straining of the muscles in parturition or in vomiting, especially when the stomach is full. Ruptures of the diaphragm have also been caused by the unskilful introduction of œsophageal bougies. We have already mentioned, moreover, that the diaphragm may be wounded by fragments of bone in fracture of the ribs.

Through rents in the diaphragm, either the abdominal organs, especially portions of the stomach, the intestine, the spleen, and the liver, may enter the thorax, or, less frequently, the lungs may drop down into the abdominal cavity. We shall return to these diaphragmatic herniæ arising in this way under the subject of herniæ (§ 194). The displacement of the above-named abdominal organs is often remarkably well borne by patients, so that they live for years with more or less discomfort (colic, dyspnœa), and then at the autopsy a large diaphragmatic hernia is found. Death sometimes follows sooner or later from strangulation, particularly of the intestine, with the escape of its contents into the thoracic cavity. As time goes on, more and more loops of intestine and other abdominal organs may enter the thorax through the rent in the diaphragm. Most of the so-called diaphragmatic herniæ are really caused by ruptures of the diaphragm. Correctly speaking, they are not herniæ, but rather traumatic prolapses. Most of them have therefore no hernial sac. In two hundred and forty-eight out of two hundred and seventy-six cases there was, according to Larcher, no hernial sac.

Severe injuries of the thoracic and abdominal organs frequently accompany those of the diaphragm, occasioning immediate or speedy death.

The symptoms of an injury of the diaphragm are very variable according to the degree of the injury itself or of the associated injuries. If the latter are absent, recovery has not infrequently been observed without serious functional disturbances. The principal symptoms of a larger or smaller rent in the diaphragm are pain in that region, especially during deep respiration and coughing. Diaphragmatic respiration is restricted as far as possible by the patient. Dyspnœa is most likely to be present when abdominal organs are displaced and enter the thorax, and the lungs and heart are compressed thereby. In such cases corresponding disturbances of the digestive organs also, with pain, colic, etc., become more and more marked. When there is displacement of the stomach and intestines into the pleural cavity, the physical signs are essentially the same as in pneumothorax—viz., a tympanitic percussion note and splashing sounds on auscultation, particularly if the patient is given some fluid to swallow. Upon distending the stomach by the injection of air, for example, or by means of an effervescing powder, the area of tympanitic percussion increases correspondingly.

In case of open wounds of the diaphragm, the course depends chiefly upon whether or not suppuration in the form of suppurative peritonitis or empyema occurs. The symptoms really depend here upon the associated injuries of the abdominal and thoracic organs which almost always occur in connection, for example, with punctured and gunshot wounds.

The prognosis of injuries of the diaphragm depends chiefly upon the associated injuries, but it is always dubious even in injury of the diaphragm alone, as more and more of the stomach and intestine may enter the thoracic cavity through a rupture in the diaphragm, and the patient die in consequence of their strangulation and perforation with diffuse septic peritonitis and empyema. Immediate death from shock has also been seen to follow the injury (see Principles of Surgery, § 63). Death ensues most frequently from the associated injuries, from internal hæmorrhage or from subsequent general peritonitis, caused, for example, by perforation of the stomach or intestines. If the patient survives the injury, the hole in the diaphragm, in consequence of the elastic retraction of the latter, remains patent, and frequently even increases in size the more the abdominal organs are displaced into the thoracic cavity.

The diagnosis of an isolated injury of the diaphragm is difficult or impossible, especially when no displacement of the abdominal organs into the thoracic cavity has occurred. If the latter exists, however, the physical signs are sufficiently characteristic.

In case of so-called internal strangulation, one should always think of the possibility of a diaphragmatic hernia.

In case there are no complicating injuries to other organs, the treatment of those of the diaphragm is at first essentially symptomatic.

Suture of the rent in the case of fresh wounds is indicated only in exceptional cases, but, as many instances show, it is perfectly feasible. More active measures in dealing with injuries of the diaphragm have been recently recommended, and, in my opinion, properly so (Delahouse, Riedinger, Horoch, Przewoski, Sawicki, Postempski). In suitable cases the hole in the diaphragm may be closed by suture preferably from within the thoracic cavity after reposition of any prolapsed abdominal organs. Postempski, Manara, Ricolfi, and De Nicola have reported successful cases of this sort. Generally speaking, one resects the rib just below the wound, and through this opening sutures the hole in the diaphragm. The best method both for fresh or old ruptures is to make a sufficiently large opening into the thoracic cavity by forming a flap of soft parts and bone, which may be done, for example, by uniting two vertical lateral incisions by a transverse incision either above or below, so that, after a lateral division of the ribs, the flap may be reflected either upward or downward at the proper intercostal space. Rydygier recommends the following method: A horizontal incision about twelve centimetres long is made in the fourth or fifth intercostal space, beginning at the costal cartilages. From the posterior end a vertical incision is made downward across three or four intercostal spaces. The triangular flap of skin, muscle, and bone, which is thus formed after division of the ribs, is turned downward and toward the median lines. After the wound in the diaphragm has been made sufficiently accessible in this way, it is closed by suture. Cicatrized ruptures are of course freshened beforehand. Larger defects could be closed by pedunculated flaps of skin, the tension of the diaphragm being relieved perhaps, if necessary, by sawing through the proper ribs. Only in exceptional cases would one be able to make a fresh or old rupture in the diaphragm accessible from within the abdominal cavity. In case of strangulated diaphragmatic herniæ, one has sometimes, after performing laparotomy, failed to find either the strangulated intestine or the hernial ring. In one case of strangulated hernia of the diaphragm reported by Naumann the reduction of the hernial contents could not be accomplished after laparotomy, in spite of widening the hernial ring, owing to the negative pressure in the pleural cavity. Neumann therefore recommends opening the pleural cavity in addition to performing laparotomy in order to do away with this negative pressure. It is simpler to reduce diaphragmatic herniæ from within the thoracic cavity, as has been successfully done by Postempski, for instance. In suitable cases of strangulated diaphragmatic hernia reduction has been attempted, after Nussbaum, by introducing the hand into the rectum, a method which seems to me, however, scarcely

to be recommended. In case of the escape of the contents of the intestines and stomach into the thoracic cavity, thoracotomy should be performed at once.

Among the malformations of the diaphragm, its absence, which occurs very rarely, may be mentioned. Children in whom the diaphragm is more or less completely wanting usually die soon after birth, though they occasionally live several years. Riedinger mentions the case of a boy, in whom the diaphragm was completely wanting, who lived to be seven years old. Only a portion of the abdominal organs lay in the thoracic cavity. In other cases in which the diaphragm was wanting, all the abdominal organs have been found displaced into the thorax. Congenital defects and gaps in the diaphragm, with or without protrusion of the abdominal contents into the thorax, occur principally on the left side, being, according to some authors, six times as frequent on the left as on the right where the liver acts as a protection. With reference to congenital diaphragmatic herniæ, the reader is referred to the subject of herniæ (see § 194).

Of inflammatory processes of the diaphragm, its inflammatory perforations are especially important. They arise from suppurative processes within the thoracic and abdominal cavities which break through the diaphragm from one cavity to the other. These perforations of the diaphragm may result from diseases of the digestive tract—e. g., from perforations of the stomach and intestine with the formation of circumscribed abscesses (subdiaphragmatic fæcal abscesses), from abscesses of the liver, the kidneys, and the spleen, from echinococcus cysts of the liver, etc. These suppurative processes in the abdominal cavity perforate by preference the thin intermuscular spaces which were described above (pages 689–691). I have collected from literature forty-eight cases of communication between the gastro-intestinal canal and the thoracic cavity. Twenty-two involved the intestine (fourteen the large intestine and eight the small intestine) and twenty-six the stomach. Perforation of ulcers of the stomach and intestine, which led to subphrenic abscesses, was the principal cause. I cured by thoracotomy one case of thoracico-intestinal fistula which probably had arisen from perforation of a subphrenic fæcal abscess into the thoracic cavity in consequence of rupture of the duodenum. In the thoracic cavity there was a large amount of food, especially plum skins. The perforation opening in the diaphragm and in the intestine gradually closed, and, as was said, the patient fully recovered (see von Langenbeck's Archiv, Bd. xxvii). Perforation of subphrenic abscesses into the pericardium through the intermuscular space mentioned above (page 690) has also been observed—e. g., following ulcers

of the stomach or abscesses of the spleen. Subphrenic abscesses resulting from perforations of the stomach and intestine have been described in detail, especially by Leyden. They usually lead, as they contain air, to a subphrenic pyo-pneumothorax. It making the diagnosis it is of importance that the thoracic cavity is at the beginning intact, that symptoms of peritonitis, indigestion, disease of the stomach, intestines, liver, kidneys, or spleen, exist at the outset, and that then, more or less suddenly, the symptoms of an empyema or pyo-pneumothorax make their appearance.

In other cases the course is reversed. A primary suppuration in the thorax—such as empyema, abscess of the lung, suppurative mediastinitis or pericarditis—breaks through the diaphragm externally or into the abdominal cavity, and here produces localized or general peritonitis, or spreads between the peritonæum and the muscles of the back, and sometimes perforates the latter (Curschmann). Subphrenic abscesses may also follow pneumonia and endocarditis, with or without the intervention of an empyema. Helferich observed a subphrenic abscess following paronychia.

I recently operated upon two cases of subphrenic pyo-pneumothorax which had arisen from perforation of a tubercular abscess of the lung through the diaphragm. The abdominal cavity was completely shut off in both cases by inflammatory adhesions, so that there was no general peritonitis. Both patients recovered. The fistula of the lung which existed at first closed. One of the patients is still alive, and the other died several months later from tuberculosis of the lungs. In some cases an empyema ruptures into the intestine, so that a large amount of pus is discharged *per rectum*.

In all cases of perforation of the diaphragm, in consequence of suppurative inflammations within the thoracic or abdominal cavity, the treatment consists chiefly in evacuation and drainage of the pus collection in the thoracic cavity, or beneath the diaphragm. In case of empyema or pyo-pneumothorax, thoracotomy, with resection of one or more ribs, and drainage should be performed. Suppurative pericarditis should likewise be treated by incision and drainage (see the technique of these operations, § 126, page 701, and § 127, page 710). The same is true of subphrenic abscesses.

§ 125. **Inflammatory Processes in the Soft Parts and Bone (Ribs and Sternum) of the Chest Wall.**—Of the inflammatory processes in the external soft parts of the thorax, furuncles and carbuncles may be mentioned first, which are especially common on the back and the nape of the neck. Their course and treatment have been already sufficiently described (page 20), to which the reader is referred.

Acute phlegmonous inflammations on the chest are not very common. The diffuse suppurative processes are especially to be mentioned, which occur in the supraclavicular and infraclavicular fossæ, and posteriorly over the scapula in connection with suppurative inflammations of the lower jaw, alveolar abscess, parotitis, angina Ludovica, etc. The lymphatics of the neck and the lymphatic glands situated above and below the clavicle are instrumental in the production of these inflammations and suppurations, which not infrequently spread for a considerable distance beneath the broad muscles of the front and back of the thorax, and in the direction of the axilla. The suppurative processes also which sometimes occur in the connective tissue of the pectoralis major originate, no doubt, in a similar way from primary disease of the head and neck or of the nipple. It is only rarely the case that these acute suppurative inflammations are located in the mucous bursa lying beneath the pectoralis major. In consequence of subacute and chronic inflammations of this bursa, characteristic friction sounds are sometimes heard—e. g., when the arm is moved—much the same as in chronic inflammations of other bursæ.

Suppurative processes beneath the scapula deserve especial attention, as they may be difficult to diagnose. Death has occurred from pyæmia and sepsis because the pus focus beneath the scapula was not recognised. It is best in such cases to make a trial puncture with a long, fine trocar, and, if pus is found, to lay open the abscess by a sufficiently free incision.

Acute phlegmonous inflammations of the outer soft parts of the thorax seldom—scarcely ever, in fact—rupture internally, but much more frequently externally, partly because the intrathoracic fascia and the pleura are thickened by new inflammatory layers, and partly because the pus can spread with greater ease beneath and above the broad muscles of the front and back of the chest.

Chronic abscesses of the external soft parts of the chest arise chiefly from tubercular processes on the ribs and on the sternum, or from tubercular empyemata and abscesses of the lungs that have broken through externally. All these chronic tubercular abscesses are called cold abscesses, and sometimes reach a considerable size (see also Principles of Surgery, § 83, page 417). The best way is to open up these cold tubercular abscesses thoroughly under antiseptic precautions and scrape them out energetically with a sharp spoon. A tubercular bone focus on the sternum, the ribs, or the scapula is then almost always found as the cause, or a narrow fistula leads inward, and we have then to do with a tubercular empyema or a lung abscess.

Abscesses of the chest wall may also be due to actinomycosis, most

commonly from the spreading of an actinomycotic focus of the lung that has become adherent to the costal pleura. In actinomycosis the pus contains the characteristic yellow granules, and the inciter of the disease, the actinomyces (see Principles of Surgery, § 86, page 442). Rotter observed a patient with numerous abscesses on the left half of the chest who, after an illness of about six months, died of marasmus. In the upper lobe of the lung the primary actinomycotic focus was found which had been broken through the very much thickened and adherent pleura. I saw several years ago a very similar case in a teacher who had probably contracted the disease while staying in the country at the farm of a peasant where there was a cow which had actinomycosis.

Acute and Chronic Peripleuritis.—Acute or chronic peripleuritic abscesses are situated between the costal pleura and the other soft parts of the chest wall. They are not infrequently of large size, and there are sometimes several abscesses which have arisen primarily or, more frequently, secondarily, in the peripleuritic connective tissue. In acute cases, peripleuritic suppurative processes begin with a chill. The patient complains of pain in the side that is affected and of more or less pronounced dyspnœa. If the suppuration increases, the symptoms of a circumscribed pleuritic exudation appear, and a fluctuating swelling can usually be made out on the outer surface of the chest which feels tense, especially during expiration. These acute abscesses also have little inclination to break through inwardly into the pleural cavity.

Chronic cases of peripleuritic suppuration are usually secondary to tubercular caries of the ribs or tubercular empyema.

In my opinion, primary peripleuritic inflammations are very rare. Whether acute or chronic, they almost always result from the extension of an inflammation in the immediate neighbourhood or within the thorax.

The diagnosis of peripleuritis is often impossible at the outset. When compared with empyema, the following differences usually exist: Aside from external fluctuation which may be present, it is characteristic of a peripleuritis that the exudate is sacculated, that the area of dulness does not vary with a change in the position of the patient, that the area of dulness may be at any part of the chest, and that above and below the same there is normal percussion and auscultation, whereas in an empyema the exudate is usually found in the lower portions of the chest.

The prognosis of suppurative peripleuritis is often unfavourable for the reason that it is recognised too late and the suppuration has then spread too far.

The treatment is the same as that for deeply seated abscesses. One divides the skin with the knife and pushes in a dressing forceps, a closed artery clamp, or a grooved director, until the abscess is reached. One must always, if possible, determine the primary cause (pleura, bone, etc.), and then apply the necessary treatment.

Pleuritis Rheumatica.—Fiedler in particular has advanced the theory that a great many cases of acute pleurisy are the result of a "rheumatic" infection and that they are etiologically identical with the joint affections and

cardiac inflammations which are found in acute polyarticular rheumatism. I share this view, and consider this etiology of great importance as regards treatment. Just as in acute articular rheumatism, the salicylates act very favourably in this rheumatic form of pleurisy.

Inflammatory Processes in the Bones (Ribs and Sternum).—Of inflammatory processes in the ribs, acute periostitis and acute osteomyelitis are of rare occurrence. They are treated according to the rules given in Principles of Surgery (§ 104, pages 614–616). In the course of typhoid fever and other infectious diseases metastatic inflammatory processes sometimes occur in the ribs.

The most frequent form is the chronic tubercular inflammation or tubercular caries of the ribs. This occurs both in children and adults, and may be primary or secondary to tubercular peripleuritis, pleurisy, empyema, tuberculosis of the adjacent soft parts, etc., or metastatic in case of general miliary tuberculosis.

Caries of the ribs begins either as a tubercular periostitis or osteomyelitis, usually on the anterior portion of the rib in the form of a slowly increasing, circumscribed, painless swelling of the same. Fluctuating cold abscesses are formed in time which reach a considerable size, and may lead to burrowing of pus beneath the muscles, even as far as the abdominal wall. These cold abscesses very seldom break through inwardly into the sound pleura or into the lungs, because the pleura and the intrathoracic fascia become very much thickened, and the pus can spread more easily beneath the muscles. It therefore ruptures externally, as a rule, and a fistula varying in size results. One comes with the probe upon thickened periosteum or upon carious or smooth necrotic bone. The tubercular sequestra of the ribs are usually small and permeated with grayish-red and yellow tubercles, as is characteristic of tuberculosis. Caries of the ribs is often multiple, so that there are from five to ten and even more fistulæ. Riedinger saw one patient with about twenty fistulous openings. I have myself observed such extensive tubercular disease of the soft parts and the ribs following tubercular empyema that a large portion of the anterior wall of the thorax had to be removed. Several ribs were in places destroyed in their entire thickness. The patient recovered completely (see page 709, Fig. 351).

The diagnosis of tubercular caries of the ribs is usually easy; the circumscribed swelling, the fluctuating cold abscesses, the fistulæ and fistulous tracts leading to the diseased bone, etc., are thoroughly characteristic. Still, confusion, with lipoma, hernia of the lung, syphilitic processes, actinomycosis, tumours of the ribs, and especially with a pleuritic exudate that has perforated the chest wall, is sometimes possible.

Tuberculosis also attacks the costal cartilages. It begins usually as a tubercular perichondritis, and leads likewise to corresponding destruction of the cartilage, which, in case healing occurs, is replaced by cicatricial connective tissue. Here also it is only exceptionally that the tubercular focus breaks through into the mediastinum, into the pleural cavity, or even into the lungs, in case the tuberculosis did not originate here. Möller observed a fistula of the lungs in connection with perichondritis of the costal cartilage.

Tubercular caries occurs less frequently on the sternum than on the ribs. It begins here also as tubercular periostitis or osteomyelitis, and its course is essentially the same as on the ribs. Large, cold abscesses sometimes form here also, which somewhat more frequently break through inwardly into the mediastinum, into the pleural cavity, or into the pericardium, and so may have a fatal termination. Very marked destruction has been observed on the sternum in consequence of tubercular caries—e. g., destruction of the entire manubrium and body of the sternum, so that the pulsation of the aorta was visible through the indurated membrana sterni posterior which was still preserved (Esmarch, Waitz). If the periosteum remains intact, the sternum may be replaced by the formation of new bone after removal by operation of the diseased portion.

The diagnosis of tuberculosis of the sternum is not difficult, as a rule, and yet confusion with syphilitic processes, and with tumours of the sternum, is possible. I saw a case of large tubercular abscess of the sternum which pulsated in consequence of its situation over the aorta and the heart, so that I first thought of aneurism of the aorta. The diagnosis of a retrosternal tubercular abscess of the sternum may be difficult or impossible.

The prognosis of tubercular disease of the ribs and sternum is, so far as the local process is concerned, usually favourable, if the mediastinum, the pleura, and the lungs are intact. Usually, however, the individuals concerned are already victims of advanced tubercular disease, especially of the lungs, to which they later succumb.

The treatment of tubercular caries of the ribs and the sternum consists in thoroughly scraping out the carious focus after it has been sufficiently exposed. All the fistulous tracts must be divided in their entire length, and likewise scraped out with a sharp spoon. All pockets must be thoroughly opened up, undermined edges of the skin removed, bridges of skin divided, etc.

In case of caries of the ribs it is often necessary to resect large portions of the same. This is best done by means of bone-cutting forceps (see also Fig. 348, page 706), after the periosteum, with the thick-

ened pleura and the intrathoracic fascia, has been separated from the bone. One need not, as a rule, be afraid in doing this of opening the pleura, which has become very much thickened (see also pages 706–710). If resection of the entire first rib is necessary on account of tuberculosis or a tumour, the clavicle may be divided about in the middle, the ends forced apart, the first rib carefully exposed and removed, and the ends of the clavicle then united again by suture.

The treatment of tuberculosis of the sternum also consists in an energetic scraping out of the diseased focus with a sharp spoon after it has been thoroughly exposed. In case of a retrosternal abscess the operation is more difficult. It may prove best here to resect the sternum by elevating the periosteum, and removing so much of the bone with a chisel as is necessary for sufficiently exposing the abscess. It is sometimes necessary to remove in this way a large part or almost the whole of the sternum and the adjacent costal cartilages for caries, and complete healing may thus be secured without functional disturbance on the part of the thoracic organs.

Resection of the Sternum.—The separate portions of the sternum may be resected by themselves, or the bone may be resected as a whole. The indications for its resection are injuries, chronic inflammations, tumours of the sternum, abscesses and tumours of the mediastinum, ligation of the large thoracic vessels, etc. Among the accidents which may occur, but which are best avoided by performing the resection subperiosteally, are opening the pleura and the pericardium, as well as injury to the internal mammary artery or the large vessels.

Generally speaking, resection of the sternum is best performed by making a longitudinal incision through the skin and the periosteum down to the bone, and, if necessary, adding a transverse incision at both its upper and lower end. The periosteum is then separated from the anterior surface of the sternum, and, after the costal cartilages have been divided near the border of the sternum, the periosteum and the membrana sterni posterior are separated from the posterior surface of the bone. In this step of the operation great care is necessary to avoid wounding the membrana sterni posterior and the pleura. The internal mammary artery is to be ligated if it proves necessary (see page 672). Finally, the sternum is divided above and below with the chisel. The articulation between the manubrium of the sternum and the clavicle should, if possible, be left intact on both sides. But even after removal of the entire manubrium and the upper half of the body of the sternum the normal movement of the head, shoulders, and arms usually remains undisturbed (A. Roullies, Bessel-Hagen). Instead of these extensive resections, it is usually sufficient in tuberculosis to chisel

away a part of the sternum. The above-described complete resection is especially indicated in case of malignant tumours of the sternum.

Syphilis of the Ribs and the Sternum.—Syphilis of the ribs and the sternum usually has its location in the periosteum, less frequently in the bone. It takes the form of a circumscribed or, less frequently, a more diffuse gummatous periostitis and osteomyelitis, or of circumscribed gummata. The latter are usually painless nodules or tumours, which are at first solid and afterward gradually become softer, and which sometimes reach a considerable size, causing corresponding disappearance of the bone. As is true of all bone syphilis, syphilis of the ribs and the sternum first appears in the later stages of the disease. The syphilitic gummatous inflammations can easily be confounded with tuberculosis and the gummata with tumours, especially with sarcomata. The other manifestations of syphilis, however, which are usually present, the history of the patient, the mode of development, and the results of the microscopic examination of the syphilitic lesion ordinarily enable one to reach a correct diagnosis without difficulty.

The treatment should be chiefly of a general antisyphilitic character—mercury, and particularly iodide of potassium in increasing doses (see Principles of Surgery, § 84). There should also be suitable local treatment, especially energetic scraping with a sharp spoon in case of syphilitic caries and necrosis.

Intercostal Neuralgia.—Intercostal neuralgia—that is, pain in the intercostal nerves and their branches—first received operative treatment from Nussbaum. He permanently cured a neuralgia of twenty years' standing by stretching the eighth, ninth, and tenth intercostal nerves on both sides.

The technique of stretching the intercostal nerves is as follows: These nerves lie in a groove near the lower border of the rib and below the intercostal artery and vein. For stretching the nerves near the spine Nussbaum recommends an incision about six centimetres in length along the lower border of the proper rib. The incision begins about six centimetres from the spine. After exposing the lower border of the rib and separating the external intercostal muscle from the rib, one can easily isolate the nerve, draw it out, and stretch it in a proximal and distal direction. In Nussbaum's case the pain was located especially in the abdominal terminal branches of the eighth, ninth, and tenth intercostal nerves between the ensiform process and the umbilicus, which he also exposed and stretched by longitudinal incisions eight centimetres long between the sternum and the umbilicus, parallel to the outer border of the rectus muscle.

Intercostal neuralgia sometimes has a demonstrable cause, such as a fractured rib which has united with deformity. In such cases the chief thing is to remove the callus by resection of the rib. Seeligmüller recommends for intercostal neuralgia deep hypodermatic injections of from one to ten per cent osmic acid.

§ 126. **The Surgical Treatment of Pleuritic Exudations.**—If blood, serum, or pus collects in the pleural cavity to such an extent that they endanger life through compression of the lungs and displacement of the heart, the evacuation of the fluid is indicated under all circumstances.

Collections of fluid in the pleural cavity are, as is known, especially characterized by a corresponding dulness or flatness, absence of breathing sounds, and diminution of the vocal fremitus. Operative treatment of collections of fluid in the thorax is indicated either because the exudation compresses the lungs and the heart in a threatening manner, or because the absorption, especially of a suppurative exudation or empyema, is too slow or altogether impossible.

In every case of exudation in the pleural cavity one should at first make an aseptic trial puncture with an aspirating syringe, the needle of which has been previously sterilized by heating it red-hot over an alcohol flame and then placing it in a five-per-cent carbolic-acid solution. The needle is introduced in the middle or in the lower part of the area of dulness in the proper intercostal space—e. g., in the axillary line or posteriorly—and fluid is then aspirated by drawing the piston of the syringe. If blood or a serous fluid is found it should be evacuated by tapping, but if the trial puncture reveals the presence of pus, incision and drainage of the thorax by thoracotomy are indicated. Many surgeons—e. g., Wölfler and others—in case of suppurative effusions, try puncture and permanent aspiration, after Bülau (see page 704), which often proves efficacious, but not infrequently makes supplementary thoracotomy with resection of a rib necessary. I consider thoracotomy with resection of a rib the surest and quickest method of getting rid of suppurative effusions in the pleural cavity. The bacteriological examination of the pus that is obtained by the trial puncture is of great importance in determining the treatment or the character of the operative interference (Prince Ludwig Ferdinand, of Bavaria). Staphylococci and streptococci, as well as diplococci and tubercle bacilli, are found in the pleuritic exudation, each form of bacteria by itself sometimes, and sometimes combined with others. Most cases of empyema are due to the presence of the *Streptococcus pyogenes*, and these demand, even if the exudation is at first still serous, resection of a rib. The staphylococci exudations and the diplococci exudations are more favourable, and may even disappear spontaneously. The treatment should here depend upon the clinical course. Tubercular and septic empyemata have a bad prognosis, on account of the gravity of the underlying disease. As regards the treatment of tubercular empyemata, I share Bäumler's views. Empyemata with or without pneumothorax in phthisical patients require thoracotomy with resection of one or more ribs in case the trial puncture reveals the presence of pus cocci in the exudate. If pus cocci are not found, one should remove a part of the exudate from time to time by aspiration, in order to relieve symptoms of pressure and bring about a gradual expansion

of the lung. The same treatment should be used in the case of empyemata that have existed for some time where the lung is only slightly or hardly at all capable of expansion. If it is found that the lung gradually expands, one should then make use of the slowly working aspiration drainage of Playfair-Bülau (page 704). Empyemata which are comparatively benign sometimes develop in the course of typhoid fever and are probably caused by the typhoid bacillus. These empyemata in typhoid sometimes disappear spontaneously.

Thoracocentesis, or Aspiration of the Thorax.—This is undertaken in case of serous, hæmorrhagic, or chylous exudations (chylothorax from injury of the thoracic duct) only when, in consequence of compression of the lungs and the heart, dyspnœa exists to such a degree as to endanger life. All the fluid that is in the pleural cavity should never be drawn off at one time, and it must not be removed too rapidly, as otherwise intrathoracic hæmorrhages and laceration of the lung tissue easily occur. Dieulafoy, Fräntzel, and others say that one should never remove more than fifteen hundred grammes at one time. It is better, if necessary, to repeat the process.

The lowest point of dulness—e. g., on the back between the ninth and the eleventh ribs—should not be selected for the puncture, because the diaphragm and the abdominal organs are more easily injured and the orifice of the aspirating needle may be obstructed by the rising of the diaphragm in consequence of the gradual emptying of the pleural cavity. The needle is inserted most frequently in the axillary line between the fifth and sixth ribs, or posteriorly in the seventh or the eighth intercostal space between the seventh and ninth ribs. The skin of the patient having been disinfected, he should be in a half-sitting posture, or better, lie more nearly flat, because in the latter case syncope does not occur so easily. In making the puncture one uses an aseptic trocar of medium size or a hollow needle—Fräntzel's or Billroth's trocar, for example (Fig. 346). After inserting Fräntzel's trocar the needle is pushed back air-tight by means of the button, A, and the cock on the India-rubber tube is then opened. After inserting Billroth's trocar the needle is withdrawn air-tight as far as the point D by pulling out C, the cock A is closed, the cock B opened, and the fluid flows out. The entrance of air into the thorax is to be avoided as far as possible. One must not insert the point of the trocar too deep, for fear of injuring the lung. The fluid is usually aspirated by means of siphon action, a piston syringe, or the apparatus of Dieulafoy (Principles of Surgery, page 70). Forced aspiration must never be made use of, as it is dangerous. The apparatus devised by Alexander and by Fürbringer (Fig. 347) is also very practical. It consists of a simple glass vessel

through whose cork, which closes air-tight, two glass tubes are inserted, one of which reaches to the bottom of the glass. Both tubes are provided with an India-rubber tube one metre long and half a centimetre in diameter. The air tube is provided with a clamp. A little fluid is sucked into the bottom of the receiving vessel, the puncture is made, and the tube is connected with the trocar and works like a siphon. If so much of the exudate is emptied that the siphon action stops, suction is applied to the other tube.

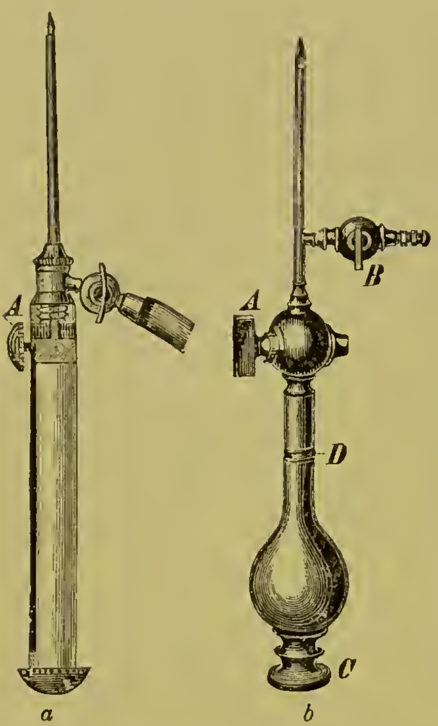


FIG. 346.—Trocar for thoracocentesis: *a*, after Fräntzel; *b*, after Billroth.

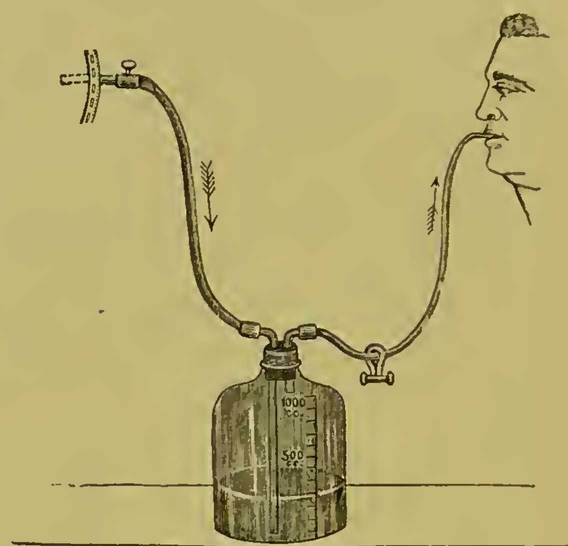


FIG. 347.—Aspirating apparatus for thoracocentesis after Fürbringer.

One should from time to time interrupt the stream by pinching the India rubber tube with the fingers, especially in case of severe coughing or syncope. If the stream stops in consequence of obstruction of the trocar by clots of fibrin, for instance, a fine elastic bougie is introduced. After the process of aspiration is over, the trocar is removed air-tight and the small puncture wound is covered with iodoform-collodion or adhesive plaster.

In order to remove the fluid completely from the pleural cavity after aspiration, Parker, Potain, and others have forced sterilized air into the cavity and thereby secured satisfactory results.

Playfair and Bülau have recently recommended puncture and permanent aspiration both for serous exudates and empyema. It is performed under local anæsthesia as follows: A large trocar is pushed through one of the lower intercostal spaces into the pleural cavity, and after removal of the stylet a soft India-rubber tube or catheter is

introduced through the trocar into the pleural cavity and the trocar is then withdrawn. The India-rubber tube, which must not be too long, remains in position permanently. It is best secured by means of two silk sutures and strips of adhesive plaster, and is connected with a longer tube by a short one of glass. The longer tube hangs down into a vessel containing a solution of bichloride and is anchored within it by a lead weight. One can watch the flow of the exudate through the glass tube. The formation of a pneumothorax can be surely avoided. If the upper India-rubber tube is closed by a clamp, the lower tube may be removed, the glass emptied, etc. There is a gradual discharge of the exudate to which the expansion of the compressed lung is proportionate. The patient can also leave his bed and go about with the aspiration bottle in his pocket. Leyden has properly recommended this very simple method for suitable cases, and it is also extensively used in Curschmann's and Heubner's clinic. The results are very good. Not infrequently, however, thoracotomy with resection of one or more ribs is subsequently necessary, particularly to remove clots of fibrin and inspissated pus. A similar method was recommended earlier by Quincke.

The methods of Riva, Potain, Robertson, and others are based upon much the same principles as that of Playfair and Bülau.

In my opinion, the very simple operation of thoracotomy with subsequent drainage, combined with the right kind of after-treatment, affords, in case of empyema, far greater certainty of success, less discomfort for the patient, and, above all, more rapid healing than Bülau's method. The latter is often, to be sure, very useful, in case of fluid exudations, but for an empyema with abundant clots of fibrin or with inspissated pus or sloughs it is not suitable, as has also been properly stated by Schede, Hofmokl, Küster, and others. The disadvantages that have been ascribed to thoracotomy—the free entrance of atmospheric air, the hindrance to the re-expansion of the lungs caused by the pressure of the air, the subsequent deformity, etc.—do not, as a matter of fact, exist.

Thoracotomy.—Thoracotomy is especially indicated in cases of suppurative or septic exudation in the pleural cavity, also in echinococcus cysts and actinomycosis of the pleura, etc. The operation in skilled hands is altogether without danger. The cases in which death has occurred were chiefly those of patients already suffering from septicæmia, pyæmia, or advanced tuberculosis.

At what part of the chest should thoracotomy be performed? Generally speaking, the same rules apply here that were given above for aspiration of the pleural cavity. In case of an encapsulated exudate,

one will naturally enter where, judging from the physical examination and the trial puncture, he will be sure to find the pus cavity and be able to drain it well. If one has the choice, the preference is given in thoracotomy also to the fifth intercostal space between the fifth and the sixth rib, in the axillary line, or, still better, posteriorly in the vicinity of the seventh to the ninth rib. It is sometimes a good plan to open the chest both in front and behind. Of late I have always, when it was possible, opened the thorax from behind in the vicinity of the seventh, eighth, or ninth rib, not by an incision between the ribs but upon them, followed by the resection of a piece three or four centimetres long from the continuity of one or two ribs, in order to be able conveniently to introduce a short, stout drainage-tube. This method gives excellent results; the discharge in the dorsal position of the patient is very satisfactory, and healing takes place more quickly.

The technique of thoracotomy is briefly as follows: If the pulse and the respiration warrant it, an anæsthetic is administered cautiously, the best way being to begin with chloroform and then use ether. I always perform the operation under antiseptic precautions, even in case of a septic empyema. If one desires to make the incision in the intercostal space—e. g., between the fifth and the sixth rib in the axillary line, or posteriorly between the seventh and the ninth rib—he makes an incision from three to six centimetres long, according to the age of the patient, through the skin and the intercostal muscles, parallel to the above-mentioned ribs, and then opens the pleural cavity by means of some blunt instrument, such as a grooved director or dressing forceps, whereupon the pus usually gushes out forcibly. If one desires to avoid the resection of a piece of the rib, it is sometimes sufficient for the introduction of the drainage-tube to remove a piece of bone from the opposite edges of two ribs by means of rongeur bone forceps. As a rule, however, the removal of a piece three or four centimetres long from the continuity of a rib is to be recommended in order to secure better drainage, and it is therefore more advantageous to make an incision at once, as above mentioned, upon the seventh, eighth, or ninth rib posteriorly, or upon the fifth rib in the axillary line. After dividing the skin and the periosteum, the latter is separated by means of a periosteal elevator, together with the soft parts on the anterior and posterior surfaces of the rib, and a piece of the bone

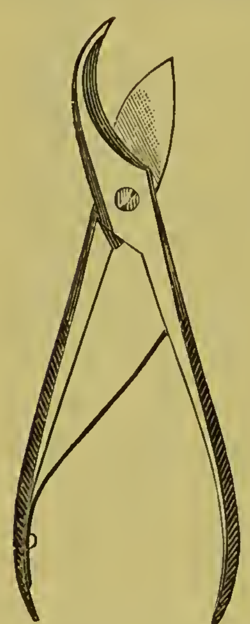


Fig. 348.—Bone forceps used in the resection of ribs.

about three or four centimetres long is then resected with curved bone-cutting forceps (Fig. 348). The pleura is now sufficiently opened, parallel to the ribs, for inserting a short, thick drainage-tube by puncture with the knife, or bluntly with a grooved director and a dressing forceps, care being taken of the intercostal arteries. The tube is secured in position by means of a safety pin. I irrigate the thorax with lukewarm, non-poisonous, antiseptic solutions (three per cent boric acid, one third of one per cent salicylic acid, one tenth of one per cent permanganate of potash) only in case of septic empyemata with thick, offensive pus, but I by no means regard it as absolutely necessary. Patients have repeatedly died very suddenly after irrigation of the pleural cavity following thoracotomy. If the pus is not offensive I omit the irrigation, only taking care to see that it is removed as completely as possible from the thorax. To accomplish this, one should give the patient different positions, letting him sit up, then lie on his side, or lifting him up by the legs. After the operation is completed, an antiseptic protective dressing is applied which is changed as soon as it is wet through by the discharge or if the temperature rises. The dressing must be changed more frequently at first than afterward. In the after-treatment also irrigation of the thorax is not to be recommended except occasionally in case of ichorous pus or when inspissated masses of fibrin or pus have to be removed. One must always take care that the drainage-tube does not become obstructed, and it should therefore be taken out and renewed whenever the dressing is changed. It can often be permanently removed after a few days, but in case of a septic empyema it must remain longer, often for weeks, and the large abscess cavity diminishes in size only very gradually.

Healing takes place in an empyema, as in all abscesses, from cicatricial contraction of the surrounding soft parts, and especially in consequence of the gradual expansion of the retracted lung. Complete return to the normal may thus follow, attended usually by adhesion of the visceral to the costal pleura.

If in cases of old empyemata the lung, in consequence of prolonged compression, is no longer capable of expansion, the abscess cavity in the thorax can not completely heal and an empyemic fistula persists, as the rigid, bony wall of the thorax does not yield to the cicatricial contraction. In the most severe cases the involved lung is found firmly contracted, the size of a fist, in the upper part of the pleural cavity. In these cases of chronic empyema of long standing with fistulæ, healing can only be secured by such resection of the ribs as shall enable the thoracic wall to yield and thus follow the cicatricial contraction. The best way is to resect pieces from four to six centimetres long, or even

longer, according to the age of the patient, from several ribs, after Estlander. After such extensive resections of the ribs the pleural cavity should be opened in several places parallel to the ribs at its deepest part and scraped with a sharp spoon if necessary. I have repeatedly found it serviceable to pack the pleural cavity with iodoform or bichloride gauze in the same way as in a case that was operated upon by Sprengel and which is represented in Fig. 349. In spite of extensive resections of the ribs, I have not seen scoliosis result in adults. In one case it existed temporarily at the beginning, but gradually disappeared under proper treatment with a plaster-of-Paris corset and massage. In children and among growing individuals in general, extensive resections of the ribs should be avoided, as permanent deformities of the chest and spine may otherwise result. Moreover, the thorax of a child is so yielding that extensive resection of the ribs is usually unnecessary. In place of Estlander's operation Jaboulay divided the insertions of several ribs from the sternum, the first to the seventh, for instance, and secured good results.

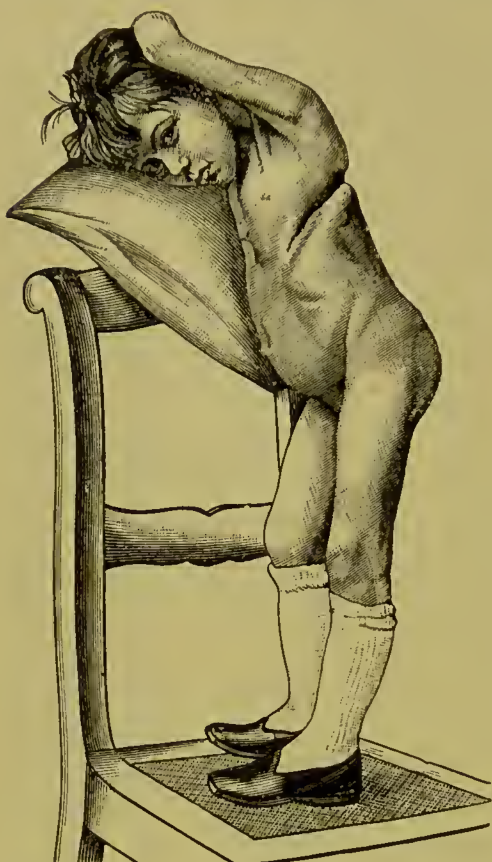


Fig. 349.—Operation for empyema consisting in subperiosteal resection of two ribs and packing the pleural cavity with iodoform gauze.

In severe cases one may also, after Schede, cut a large skin-flap with its base upward (Fig. 350), then make a correspondingly large opening in the wall of the thorax by subperiosteal resection of the ribs and the soft parts, making it sufficiently broad and as high as the empyemic cavity. The flap of skin is then drawn over the defect so that it may unite with the pleura. Park has likewise made extensive use of Schede's thoracoplasty with the greatest success. One may also adopt Delorme's method of making a generous exposure of the interior of the thorax for empyema or operations on the lung by the formation of an osteoplastic flap extending from the third to the sixth rib and with its pedicle above and behind. In front, both the ribs and intercostal spaces are divided; and behind, the ribs only are divided or resected

to a slight extent. This osteoplastic flap is subsequently replaced and united by suture.

When the patient has tubercular disease, caution must be exercised in performing extensive resections of the ribs, and I agree in general with Fräntzel, Fiedler, Senator, and others that one should here restrict himself in the main to a symptomatic treatment, including repeated aspirations. There are exceptions, however, as the following case upon which I operated shows. Schede also had three recoveries out of four patients with acute phthisis who were operated upon.

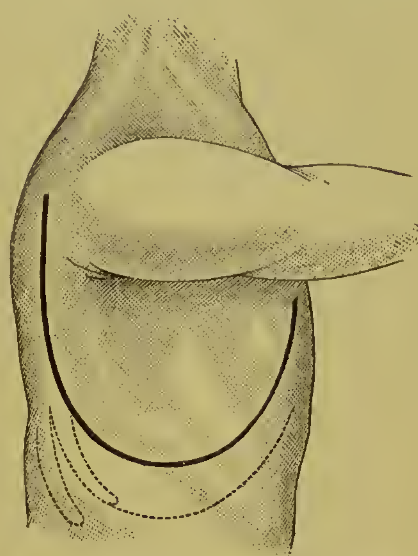


Fig. 350.—Thoracoplasty after Schede.

In a very desperate case of empyema of two years' standing, which had been treated by resection of the ribs without success, with numerous fistulæ and extensive tuberculosis of the pleura, the ribs, and the soft parts, especially on the anterior chest wall, I resected the entire anterior thoracic wall (Fig. 351). The ribs and the soft parts were the seat of tuberculosis, and I found in the thorax a drainage-tube ten centimetres long which had slipped into the pleural cavity during previous treatment and had lain there for months. The left lung, which was the size of a fist, lay firmly compressed and adherent in the upper part of the left pleural cavity, and the heart was displaced to the right. In performing resection of the whole anterior wall I preserved as much of the skin as possible, and laid this flap over the small, firmly adherent lung. The rest of the pleural cavity was scraped out, left open, and packed with iodoform gauze. I finally transformed the open, granulating left pleural cavity into a skin surface by skin-grafting. The patient completely recovered and is again active as a merchant. The open pleural cavity has the appearance of the skin. The right lung and the heart,

Fig. 351.—Resection of the anterior chest wall for chronic empyema with tuberculosis of the soft parts and ribs; cure.

which is displaced to the right and is easily felt, perform their functions well. No trouble of any kind exists aside from a moderate emphysema of the right lung. Similar cases have been operated upon according to my method by Thiersch, Güterbock, and others. By the resection of a piece of bone eight centimetres in length from the eighth, ninth, and tenth ribs Israel exposed and arrested a dangerous hæmorrhage from a tubercular ulcer of the pleura.

Pulsating Empyema.—In pulsating empyema, which almost always occurs on the left side, the diseased side of the chest pulsates synchronously with the heart beat. The vibrations of the thorax sometimes extend over a large surface of the chest wall and are sometimes confined to the area over the pleuritic exudation. This condition, which is rare, can be easily distinguished from an aneurism by careful auscultation and percussion. The heart is always displaced to the right and held there by adhesions. The left lung is usually very atelectatic.

§ 127. **Puncture and Incision of the Pericardium** are indicated when it is filled with blood, serum, or pus, in order to overcome the pressure of these fluids on the heart and the resulting disturbance in its action.

Puncture (paracentesis) of the pericardium was first performed by Romero in 1819. It has yielded very favourable results of late. Hindenlang has tabulated sixty-five cases of paracentesis of the pericardium, with twenty-one recoveries. Riedinger computes the number of recoveries at about thirty-seven to forty per cent. Fiedler properly emphasizes the fact that puncture of the pericardium is in the main only a palliative operation, especially in case of exudations due to tuberculosis or carcinoma. Still the value of paracentesis must not be underestimated. As is true of thoracocentesis, puncture of the pericardium is indicated in case of serous exudations (hydropericardium). If a large amount of pus is present, incision and drainage are to be preferred. Fiedler recommends incision of the pericardium for hæmorrhagic exudations also.

When there is an exudation in the pericardium with threatening symptoms, a trial puncture should always be made at first with an aseptic aspirating syringe to determine the nature of the exudate, and puncture or incision of the pericardium should then be undertaken according to the conditions found.

The technique of puncture or paracentesis of the pericardium is as follows: The area of flatness should be marked out in order to determine the place where the puncture is to be made. It has been made in the third, the fourth, and the fifth intercostal space, close to the border of the sternum and at a distance of three to four centimetres from it. Generally speaking, one will be most sure to strike the free pericardium

between the fifth and the sixth ribs, close to the left border of the sternum (see also page 689). Puncture is best performed, while the patient is in a half-sitting posture, with a hollow needle which has been sterilized by boiling for five minutes in a one-per-cent soda solution, or with a fine trocar. Riedinger recommends the trocar devised by Heuss. Fiedler uses for puncture a trocar without a transverse plate, which he pushes obliquely through the side of an India-rubber tube and out through its end. After inserting it the stylet is drawn out of the canula, and the India-rubber tube slips over the latter. The fluid may be collected under water, and the entrance of air into the pericardium surely avoided. One may also make use of aspiration, just as in tapping the pleural cavity (see page 703). The hollow needle or the trocar is introduced obliquely inward and upward. When the point of the instrument has entered the pericardium, it must be lowered immediately and drawn out of the canula, so as not to injure the heart or the coronary artery, accidents that have actually occurred. Puncture has repeatedly been unsuccessful because the pericardium was not opened at all, but the hollow needle was pushed into the lung or the pleura, or even into the heart, which had become adherent to the pericardium.

If the trial puncture reveals a suppurative effusion within the pericardium, the latter is opened freely by incision after it has been reached by dissection. It is then drawn a little forward out of the wound, secured by two catgut sutures (Gussenbauer), and opened with a knife or scissors. Riedinger recommends that the opening in the pericardium be made no larger than the circumference of the drainage-tube that is to be introduced. Finally, an antiseptic protective dressing is applied. Among nine cases of pyo-pericardium treated in this way, four, according to Sievers, recovered.

§ 128. **The Surgical Treatment of Abscess of the Lung and other Pulmonary Diseases.**—As early as the seventeenth and eighteenth centuries surgeons expressed themselves in favour of an operative treatment of abscess of the lung by incision or pneumotomy (Baglivi, Barry, A. G. Richter). More recently Krönlein, E. Bull, Bacchini, the author, and others have successfully operated upon abscesses of the lung and bronchiectatic cavities. W. Koch and Mosler deserve the credit of having again taken up the question of operative treatment of pulmonary diseases, especially abscesses of the lung. Mosler was the first, in his treatise upon the surgery of the lungs (1883), to collect the older literature of the subject. In the observations recorded in literature regarding "abscesses of the lung" that had received operative treatment, actinomycosis may sometimes have been present. Operative treatment

is also indicated, under certain circumstances, in case of gangrene of the lung and foreign bodies. The prognosis of gangrene of the lung is so unfavourable that one should, no doubt, always venture upon operative interference. Single tubercular cavities, with retention of secretion, high fever, etc., are especially adapted to operative treatment. Sonnenburg in particular has combined operative treatment of cavities of the lungs with the administration of Koch's tuberculin. In speaking of abscesses of the lung we mean etiologically very different processes. According to Park, of eighty-four cases of "abscess of the lung" that were operated upon, twenty-eight terminated fatally (a mortality of thirty two per cent). Of fourteen cases of gangrene of the lung, eight, according to Slawyk, were cured by operation; and of nineteen cases, according to Seitz, only four were cured, four were improved, and eleven terminated fatally. We shall take up the operative treatment of tumours of the lungs more in detail in § 131, page 720.

The surgical treatment of diseases of the lungs consists, generally speaking, either in incision (pneumotomy) or in resection of a portion of the lung (pneumectomy). Pneumectomy comes especially into consideration in connection with tumours of the lung.

In operating on circumscribed processes within the lung, such as gangrene and abscesses, one should choose particularly those cases where the pus can not be sufficiently evacuated through the bronchi and the patients are become progressively weaker from high fever, etc. The superficial abscesses of the lung in which the pulmonary and the costal pleura are adherent are the most favourable for incision. In order to determine whether the layers of the pleura adhere or not, Fenger advises the introduction of an aspirating syringe after incision of the intercostal muscles. If it moves synchronously with the respiratory movements, there are no adhesions at this place; otherwise there are. The question whether abscesses of this kind, in which the layers of pleura do not adhere, should also receive operative treatment, is differently answered by individual authors. E. Bull recommends operation in such cases also, especially if threatening symptoms exist, and he advises bringing about adhesions between the layers of pleura by letting a trocar remain in place, or by the application of a caustic. Riedinger and Rout recommend in suitable cases suturing the lung to the outer wound—that is, uniting the two layers of pleura by a circular suture. If, therefore, in a pulmonary abscess there are no pleuritic adhesions, or if there is a doubt about them, one should, if the whole operation is performed at one time, unite the pulmonary with the costal pleura by a circular suture; or, if there is no danger in delay, one may

operate in two stages in the following manner, as Quincke has also done in several cases with good results : After resecting a piece four or five centimetres long from one or two ribs in the vicinity of the lung abscess, and dividing the external intercostal muscles, chloride-of-zinc paste is laid in the wound and renewed every second or third day. Adhesion of the pleura with the chest wall over a considerable area is then completed in about two weeks. Then, after a trial puncture, an incision is made into the abscess, and a drainage-tube or iodoform gauze inserted. Healing sometimes takes place after resection of one or more ribs, and cauterization with chloride of zinc without opening the abscess—a fact which may be of value in connection with bronchiectatic and tubercular lung cavities.

If the abscess is large, it will be necessary to make two or more incisions and counter-openings, resect several ribs, etc. In case of a deep-seated abscess, the lung tissue over the pus cavity can be divided with the thermo-cautery, which may also be used for enlarging the opening in the lung (Mosler, Vogt, Sonnenburg). A similar course should be taken for the removal of any foreign body. The opened cavity in the lung is packed with sterilized gauze. As regards the after-treatment, the same general rules apply as in thoracotomy (see page 707). For the operative treatment of tumours of the lung, echinococcus cysts, and actinomycosis, the reader is referred to page 720.

§ 129. **Mediastinitis.**—We shall consider here only the acute and chronic suppurative inflammation of the cellular tissue in the anterior and posterior mediastinum. It may be primary, particularly after injury of the mediastinum, and secondary to diseases of the ribs, the sternum, the pleura, the pericardium, the spine, or the œsophagus—e. g., after perforation of the latter by a foreign body ; and, furthermore, to suppurative processes in the neck, tubercular disease of the lymph glands of the neck and in the thorax, etc. Mediastinal abscesses, partly in consequence of their origin and partly from secondary involvement, sometimes communicate with the œsophagus, the trachea, the bronchi, the pericardium, etc.

The symptoms of suppurative mediastinitis are, as a rule, very severe. Regarding inflammations in the anterior and posterior mediastinum, resulting from injuries and inflammations of the neck, and particularly of the œsophagus, the reader is referred to §§ 93, 94, and 110. In case of acute suppuration the symptoms are high temperature, great pain, a feeling of oppression and weight, combined frequently with dysphagia and respiratory disturbances.

In cases of chronic collections of pus in the mediastinum there are essentially the same symptoms of pressure referable to the heart and

lungs (disturbances of respiration and circulation, dysphagia, etc.). Later on symptoms arise corresponding to the progress of the suppuration and perforation of the abscess—e. g., into the pericardium or into a bronchus. Bardeleben saw paralysis of the diaphragm in consequence of pressure upon both phrenic nerves. Large abscesses sometimes point to one side of the sternum, and frequently rupture externally between the costal cartilages.

The diagnosis of mediastinitis is always difficult unless the abscess points in the anterior mediastinum to one side of the sternum, or the character and location of an injury or disease make inflammation of the cellular tissue of the anterior or posterior mediastinum probable.

The prognosis of mediastinitis is usually unfavourable. Death commonly ensues from sepsis or pyæmia, from miliary tuberculosis, in case of tubercular inflammation, from perforation of the pus into the pericardium or into the pleural cavity, etc. It is most favourable when the suppuration spreads anteriorly, and the pus, either from spontaneous perforation or an incision, can escape externally.

Treatment of mediastinitis is only possible when the abscess is accessible by operation. Abscesses of the anterior mediastinum which point to one side of or above the sternum may be opened with preservation of the sternum or removal, at the most, of its border with the chisel. In case of retrosternal abscesses more extensive resections of the sternum are necessary, for the technique of which the reader is referred to page 700. The best method of dressing is to pack the wound with iodoform gauze, making the patient lie on his side or abdomen for a time after the operation.

In case of surgical affections of the posterior mediastinum, the incision, according to Quénu and Hartmann, should not be made close to the spine, but farther to the side, on a line with the angles of the ribs, between the median border of the scapula and the spinous processes, and always on the left side. One cuts down to the ribs, resects a piece two to three centimetres long, for example, or even longer, from one or more ribs, according to the necessity of the case, detaches the costal pleura with a blunt instrument, and can then pass the finger into the posterior mediastinum, and has a view, according to the length of the incision, of the hilus of the lung, the aorta, and the œsophagus from the root of the bronchi down to the diaphragm. One should, according to Quénu and Hartmann, always enter the posterior mediastinum on the left side, on account of the anatomical relations of the pleura, which on the right side passes in for a considerable distance between the vertebral column and the œsophagus.

§ 130. **Tumours of the Chest Wall.**—Aside from those of the mamma, tumours of the thoracic wall are not very frequent.

In the skin of the back of the thorax sebaceous cysts or atheromata occur most frequently and are very often multiple. Dermoid cysts may be situated upon, to one side of, or behind the sternum. Retrosternal dermoid cysts sometimes come to view alongside of or above the sternum.

The most frequent tumour of the chest wall is the lipoma, which is observed especially on the back and sometimes reaches a very large size—that, for instance, of a child's or a man's head. Billroth removed an enormous lipoma that reached from the neighbourhood of the scapula to the calf of the leg. The tumour was carried by the patient in a bag made for the purpose. Its weight was one third of that of the entire body, and it had a pedicle as large as a man's thigh. Lipomata are less common on the front of the chest. They are sometimes observed here behind and alongside the mamma and beneath the pectoral muscle. They are sometimes pedunculated and sometimes sessile. More diffuse lipomata also occur on the back of the neck, in the infraclavicular fossa, in the neighbourhood of the scapula, etc., much the same as on the front of the neck (see page 557, Fig. 284). As the result of pressure or unsuitable treatment, superficial necrosis of the skin with ulceration sometimes occurs over large lipomata.

Soft and hard fibromata of the back also often attain a considerable size (see Principles of Surgery, page 747).

The various capillary, arterial, or venous forms of angeiomata occasionally occur in the skin of the chest, especially cavernomata (see Principles of Surgery, page 755 ff.).

Lymphangeiomata (see Principles of Surgery, page 758) sometimes form upon the chest painless lobulated tumours which may easily be mistaken for lipomata. Upon puncture of lymphangeiomata an amber-yellow or colourless fluid is usually obtained.

Subpleural tumours sometimes occur which may lie partly within and partly outside the thorax. The part that is located within the thorax is either covered by the intact pleura, or in other cases the pleura also may be perforated, particularly in case of malignant sarcomata. Gussenbauer successfully removed a subpleural lipoma of this kind partly within and partly outside the thorax, which was found behind the mammary gland of a woman forty-two years old (Fig. 352). The two tumours (Fig. 352 *a* and *b*) were united by a small connecting pedicle.

The ribs and sternum are sometimes the seat of enchondromata, which are in part mixed tumours, particularly chondro-myxomata, chondro-fibromata, and chondro-sarcomata. They are more common on the ribs, especially in the region of the costal cartilages, than on the

sternum. They sometimes result from injuries, such as a fracture of the ribs, and may attain a considerable size (Fig. 353). Their growth is usually slow, but a very rapid increase in size has also been observed.

Fig. 352.—Subpleural lipoma behind the mammary gland which was situated partly outside (*a*) and partly inside (*b*) the thoracic cavity (Gussenbauer).

Pure chondromata are hard, painless tumours, whereas the myxomatous and cystic mixed forms are often soft in places and fluctuating, with a thin cartilaginous capsule. Chondromata of the thorax are mostly benign growths, but malignant forms which recurred and formed metastases have also been observed. In such case we usually have to do with sarcomatous chondromata.

Pure osteomata of the thorax occur but rarely, mixed forms being more common.

The malignant tumours proper—sarcoma and carcinoma—are rare, apart from those cases in which they spread from the mammary gland to the thorax. Carcinomata of the mamma involve the skin of the thorax, particularly in the form of the cancer *en cuirasse*, with the formation of numerous nodules. By the coalescence of the nodules the involved skin is transformed into a solid mass which feels like leather. Operative treatment in such cases is always hopeless. I saw an enormous ulcerating melano-sarcoma spread from a man's nipple to the thorax, so that almost the entire anterior wall of the thorax was attacked. Sarcomata occur most frequently in the periosteum or medulla

of the sternum and very often in the form of very vascular pulsating osteo-sarcomata, which may lead to the diagnosis of an aneurism of the aorta which has broken through the sternum. In other cases the pulsation of these osteo-sarcomata is communicated from the heart or the aorta if the tumour, after the destruction of the sternum or the ribs, has grown into the mediastinum.

Of parasitic tumours, echinococcus cysts and actinomycosis should be mentioned. The former are very rare on the thorax. Madelung, among others, observed an echinococcus cyst of the sternum. Actinomycosis of the thorax occurs particularly from the extension of actinomycosis of the lungs to the costal pleura and the chest wall.

The extirpation of tumours of the chest wall is accomplished under strict aseptic precautions in accordance with the general rules which we have described in the treatise upon Principles of Surgery, § 127, page 745 (Treatment of Tumours), and § 128, page 746 ff., for the different forms of tumour. The removal of the large enchondromata and sarcomata of the ribs and the sternum is the most difficult. The chief danger attending the extirpation of these tumours is in opening

a *b*

Fig. 353.—Chondroma of the ribs in a woman forty-eight years of age: (*a*) before and (*b*) after operation (H. Fischer).

the pleural cavity and the mediastinum, which often can not be avoided. The operation must therefore be performed with the use of strictly aseptic methods, in which case the pleural cavity and the mediastinum may be opened without bad results. The earlier enchondromata and sarcomata of the ribs and the sternum come to operation the greater

the probability of being able to avoid opening the pleura. In the case of enchondroma of the ribs represented in Fig. 353, H. Fischer removed large portions of the fourth to the seventh rib with the pleura attached. The defect was the size of a child's head. The lung prolapsed at first and then collapsed in consequence of the entrance of air into the pleural cavity. The patient recovered. Of sixteen cases of enchondroma that were operated upon eight terminated fatally and eight recovered; and of twelve patients with the same disease who were not operated upon, eleven (probably twelve) died before long in consequence of marasmus and growth of the tumour, with pressure upon the heart, the lungs, and the large blood-vessels (Schläpfer).

Krönlein removed a sarcoma of the sixth rib the size of a child's head. It was necessary to make a hole in the pleura as large as the palm of the hand. The tumour had become adherent to the lung, and a sarcoma nodule in the latter was likewise extirpated by drawing the lung out through the opening in the thorax. The wound in the lung was closed with catgut and the pleural cavity was irrigated and drained. The patient recovered.

In case of tumours of the sternum, it will be necessary to resect a part or the whole of this bone, as already described on page 700. König, Küster, and others have successfully removed tumours of the sternum by resection of the latter. In the case operated upon by König the pericardium had to be opened.

In the extirpation of all large tumours of the thorax with resection of the sternum or the ribs, and with wide opening of the thorax or the pleural cavity, the attempt should be made to preserve enough sound skin, if possible, to cover the defect resulting from the wound in the chest. If that can not be done, the loss of substance may be replaced by pedunculated flaps of skin from the immediate neighbourhood, or, if there is not a sufficient quantity near by, the same course may be adopted as in the case upon which I operated and which is represented in Fig. 351, page 709—that is, the lung at least may be covered by pedunculated skin-flaps and the pleural cavity may be left open and packed, and transformed later by skin-grafting into a skin gutter. Unilateral aseptic pneumothorax has no bad consequences, but one must be on his guard against opening both pleural cavities. When pneumothorax occurs simultaneously on both sides, death follows immediately from paralysis of the lungs.

§ 131. **Tumours of the Thoracic Cavity (Pleura, Lungs, Mediastinum, Pericardium, and Large Vessels).**—As regards tumours of the pleura, primary fibromata, angeiomata, osteomata, sarcomata, endotheliomata, and endothelial cancers have been observed in rare cases (see Principles

of Surgery, page 769). Secondary tumours of the pleura are more common, particularly carcinoma following carcinoma of the mamma, the thyroid gland, the œsophagus, and the stomach. Not infrequently numerous carcinomatous nodules are found in the pleura, combined usually with a sero-fibrinous or hæmorrhagic exudation. Secondary carcinomata or sarcomata of the pleura arise either from extension of the primary tumour or from metastasis. Primary echinococcus cysts of the pleura have also been observed, but, like actinomycosis, they more frequently break through from within the lung into the pleural cavity. Regarding subpleural tumours, see page 715.

The diagnosis of tumours of the pleura is usually impossible until the dulness due to the effusion can be made out, or the tumour, such as an echinococcus cyst, for instance, perforates externally.

The treatment of tumours of the pleura is essentially symptomatic. In case of malignant tumours, the sero-fibrinous or hæmorrhagic effusion, if it endangers life, must be removed by tapping the pleural cavity (see pages 703–705). If the tumour is accessible to operative treatment, the operation should be performed according to the rules laid down for thoracotomy (see pages 705–710).

Tumours of the Lungs.—In the lungs also primary tumours of the lung tissue and of the bronchi are rare. Of connective-tissue tumours the following have sometimes been observed in the lungs: Fibromata, from the size of a hemp seed to that of a hazelnut (Rokitansky, Rindfleisch), often in considerable numbers, about the bronchi; small spherical lipomata (Rokitansky, Chiari), enchondromata, and osteomata, in the form of small round nodules or irregular dentated growths which had originated in the bronchial cartilages; and, finally, sarcomata.

Dermoid cysts occasionally grow from within the mediastinum into the lungs. Büchner observed a dermoid cyst of the lungs as large as a child's head, which communicated with the aorta. Chiari described a nodular adenoma of the mucous glands of the bronchi.

Primary carcinomata of the lungs originate, according to Birch-Hirschfeld, Ziegler, and others, in the mucous glands or epithelium of the larger and smaller bronchi. They then spread into the peribronchial and interlobular lymph passages and lymph glands resulting in the formation of smaller or larger carcinomatous nodules around the bronchi. Large isolated nodules are sometimes found in the lung tissue which probably have their origin in the bronchioles or in the alveoli.

The greatest variety of tumours occur secondarily in the lungs, partly from the spreading of a new growth from the immediate surroundings, but most frequently from metastasis, living cells being trans-

ported from the primary tumour through the blood and lymph passages into the lungs.

Of tumours of the lungs resulting from animal or vegetable parasites, those due to the echinococcus are the most important, which sometimes forms cysts of large size within the lung. In the excellent work by Madelung upon the occurrence of echinococcus cysts in Mecklenburg, we find that among one hundred and seventy-six cases, nineteen involved the lungs and one the pleura. Echinococcus cysts sometimes rupture into the lungs from the pleura. The symptoms of this disease in the lungs are much the same as those of tumours of the thoracic cavity. It is easiest to confound it with pleurisy with effusion and with phthisis. There is usually abundant sputum, and also hæmorrhages and fever as in pulmonary phthisis. Echinococcus cysts of the lungs break through in the greatest variety of directions—e. g., into a bronchus, into the pericardium, into the pleural cavity, externally through the chest wall, into the abdominal cavity, into the intestine, etc. The diagnosis is usually first possible when the hooklets which are characteristic of echinococcus or shreds of membrane are found in the sputum, or when the same are obtained by trial puncture of the tumour which has become adherent to the chest wall or has ruptured externally.

The prognosis of echinococcus cysts of the lung is very doubtful. Of the nineteen cases tabulated by Madelung, only six had a fatal termination and in eight recovery was certain. Spontaneous recovery may ensue from perforation through the chest wall or into a bronchus, or else through the diaphragm into the stomach or intestine.

There remain to be mentioned those new growths which are caused by vegetable parasites, such as the tubercular nodules by the tubercle bacilli, actinomycosis by actinomycetes, glanders nodules by glanders bacilli, etc. (see Principles of Surgery, §§ 78, 83, 86, etc.).

The symptomatology of tumours of the lung is very varied. It depends mainly upon the character, the size, and the location of the tumour. Larger tumours, in consequence mainly of the space they occupy, occasion corresponding respiratory disturbances, and the destructive tumours like carcinoma and echinococcus cysts may cause symptoms similar to those of phthisis. In one case also of dermoid cyst of the lungs, which Cloetta observed, there was abundant sputum intermixed with hairs. The prognosis of the malignant tumours (carcinoma, sarcoma) is absolutely bad.

The treatment of tumours of the lung by their extirpation or resection of the involved part of the lung (pneumectomy) is, of course, only possible in exceptional cases (see also page 712). Gluck, Hans Schmidt,

Block, and Biondi have studied experimentally the question of partial resection and total extirpation of a lung in animals, and have shown that the latter (dogs) can successfully undergo these operations. After resection of certain ribs—e. g., the third to the fifth—the lung may be removed as a whole or in part, and in the latter case the wedge-shaped wound is closed with catgut. If there are no adhesions between the pulmonary and the costal pleura, the two pleural layers, in case the whole operation is performed at one time, should be united by a circular suture in order to avoid a pneumothorax; or one may operate in two stages—that is, the adhesion of the two layers of pleura may be first obtained by suture or caustic paste (see page 713). Gluck, Hans Schmidt, and Block name the following indications for performing resection of a lung: Abscess, gangrene, cavities, tumours, injuries to the lungs, and foreign bodies in the bronchi. I do not doubt that the operative treatment of pulmonary affections will be more resorted to in the future than has been the case hitherto, and I also consider it possible that the extirpation of an entire lobe may be successfully accomplished. In the case of my own which was mentioned on pages 709, 710 I placed the left lung entirely out of function without producing special disturbance, and the patient with his right lung is now in the enjoyment of full health, is active and strong, and for more than three years has been fully capable of attending to business. All new growths that adhere to the thorax are of course the most favourable for operation. It will, however, seldom be found possible to remove primary malignant tumours of the lungs, as they have often already attacked both lungs and involved the pleura, the pericardium, and the diaphragm, owing to their being recognised too late. Krönlein and Müller successfully resected a lung for tumour of the same. In order to prevent collapse of a lung that is not adherent to the chest wall and the resulting collapse of the patient which sometimes ensues, it is a good plan when the operation is performed at one sitting to hold or secure the lung while in a condition of inspiration until the wound in the chest has been closed.

If an echinococcus cyst of the lung has become adherent to the thorax or has broken through externally, it should be liberally incised, after the resection of one or more ribs, and as much as possible of the sac extirpated or scraped out. Puncture with or without subsequent injection of tincture of iodine, carbolic acid, or absolute alcohol is less effectual. If an echinococcus cyst of the lung is not as yet adherent to the pleura, one could, as in echinococcus cysts of the liver, perform the operation at two different times, by first opening the pleura and then, after adhesion of the echinococcus sac with the costal

pleura, incise the latter. In the double operation the promotion of adhesions by the use of caustic paste, after Quincke (see page 713), is to be recommended in suitable cases. It is better, if possible, to perform the operation at one time, suturing the echinococcus sac to the edges of the wound in the thorax, or uniting the pleural layers by suture, and then making the incision at once. If there is still normal lung tissue lying over the sac, it should be divided with the thermo-cautery. If extirpation of the cyst is possible, it should be undertaken. Echinococcus cysts of the liver have also been opened from within the thoracic cavity by opening the latter in the axillary line and then incising the tumour through the diaphragm and draining it (Volkmann, Israel, Leyden). Israel performed the operation in three stages.

In very rare cases, echinococcus cysts of the heart and the pericardium have been observed, Madelung mentioning only one such instance among one hundred and seventy-six cases of the disease. Distinct symptoms may be wanting in smaller tumours, but in those that are larger they are much the same as in mediastinal tumours (pain, dyspnœa, palpitation of the heart, a feeling of constriction and pressure, etc.). Death has sometimes occurred from rupture of the cyst into the aorta and the pulmonary artery. The diagnosis is usually impossible during life. In case of echinococcus cyst of the pericardium, incision of the latter would be indicated (see page 710).

Tumours of the Mediastinum.—Tumours within the anterior and posterior mediastinum are most commonly the result of the encroachment of tumours of the immediate vicinity (sternum, ribs, lung, œsophagus, etc.). Fütterer has collected from literature sixty-eight cases of mediastinal tumours, including lipomata, fibromata, tubercular or leukæmic lymphomata, exostoses, originating, for example, on the inner surface of the sternum, sarcomata, dermoid cysts, carcinomata, echinococcus cysts, etc. Krönlein reported a case from Langenbeck's clinic of a congenital lipoma of the anterior mediastinum in a female child one year old. The tumour, which was as large as a child's head, had broken through the third intercostal space on the right side and came to lie on the chest wall as a swelling the size of a fist (Fig. 354). Ten days after the extirpation the child died of erysipelas. Dermoid cysts occasionally appear above the sternum or on its lateral border, or

FIG. 354.—Congenital lipoma of the anterior mediastinum in a female child one year old which had broken through the third intercostal space on the right side. The tumour was as large as a child's head.

they may perforate into the lungs, the trachea, or the aorta. Echinococcus cysts of the mediastinum are very rare. They sometimes break through the diaphragm into the mediastinum from the liver. Sarcomata and carcinomata of the mediastinum are most frequent. The latter originate in the adjacent organs that contain epithelium, especially the œsophagus, or arise by metastasis. Primary malignant tumours of the mediastinum, carcinomata, and sarcomata originate, according to M. Letulle (Arch. gén. de méd., December, 1890), most commonly in the thymus gland or its remains. They are usually located in the upper part of the mediastinum just behind the sternum and have a tendency to spread downward toward the pericardium. The heart and the lungs are pushed backward by the growing tumours. The pleura is the first to become involved.

The symptoms of mediastinal tumours become more distinct with their increasing growth. Among these are signs of pressure upon the thoracic organs and their consequent displacement, dyspnœa, dysphagia, disturbances of circulation caused by compression of the heart and the large vessels, sometimes slowing of the pulse owing to pressure upon the pneumogastric nerve, paralysis of the vocal cords resulting from paralysis of the recurrent laryngeal nerve, and paralysis of the diaphragm from compression of the phrenic nerves. The diagnosis of mediastinal tumours is usually very difficult so long as they do not break through externally or make their appearance to one side of the sternum. They are most easily confounded with abscess of the mediastinum and with aneurism of the aorta. Extirpation of the tumour is only practicable in those cases in which it can be made accessible by resecting the sternum (see page 700, Technique of Resection of the Sternum). Access may be gained to the posterior mediastinum in the manner described on page 714. With reference to subpleural tumours see also page 715.

Aneurisms of the Aorta.—The most frequent of all aneurisms are those of the thoracic aorta. They are either cylindrical, spindle-shaped, sacculated, or diffuse. Between the individual forms there are numerous transition forms, and they combine in a great variety of ways. Aneurisms are found most frequently on the ascending aorta and on the arch of the aorta. They sometimes reach a very large size and expand in different directions—e. g., toward the sternum and the costal cartilages, or toward the lungs or the spinal column. The bone is gradually eroded by the aneurism—e. g., the sternum and the costal cartilages, and the tumour then forces its way farther and farther outward and may appear beneath the skin of the right side of the chest as a tense, strongly pulsating growth as large as the fist, or a child's or a

man's head. It may become so large as to fill the space between the sternum and the axilla. The patient has usually had syphilis.

The course of aneurisms of the thoracic aorta is very unfavourable. The dilatation of the artery almost always gradually increases, and its wall also grows thinner, so that the sac finally ruptures and immediate death ensues from hæmorrhage externally or internally. A spontaneous cure of aneurisms by the formation of thrombi, and transformation of the latter into connective tissue or calcification of the same, occurs only exceptionally and while the aneurisms are still small. The possibility of such a cure is greatest in small sacculated aneurisms. In large aneurisms also stratified thrombi are found in greater or less abundance, partly new and partly older. They increase the power of resistance in the wall of the sac but very slightly, however, and they are often detached from the inner wall again by the circulating blood, or they break down.

The treatment of aneurisms of the thoracic aorta is generally attended with little success. Surgical treatment is possible only in aneurisms of the ascending aorta and the arch of the aorta, not in those of the descending aorta. By distal ligation of the branches that come off from the aneurism—e. g., the subclavian or the common carotid, or both vessels at the same time in one or two sittings—temporary improvement only has usually been secured, a real cure probably never. Küster recommended especially ligation of the right common carotid artery. Of eleven patients with aneurism of the thoracic aorta treated by ligation of the subclavian and carotid arteries, five, according to Küster, died within ten days after the operation and six showed marked improvement, three living for several months after the operation, one for two years, during which time the improvement had continued.

Galvano-puncture of aneurisms of the aorta has also been performed repeatedly, and from my experience I can decidedly recommend it. The earlier it is tried the better. According to Bowditch, of thirty-seven patients treated in this way, seven were cured. I have used the method in nine cases. In the first case I secured, in thirteen sittings, which covered a period of twelve weeks, a distinct contraction of the sac and a mitigation of the subjective symptoms. This diminution in the size of the aneurism has continued for four years, so that the patient himself is extremely well satisfied. Of the other cases, striking improvement continues as yet in two, the aneurism remained stationary in three, and three, in whom the disease was too far advanced, died.

The technique of galvano-puncture is briefly as follows: It is performed, with antiseptic precautions, by means of long, fine steel needles, which are stuck about five centimetres deep into the sac of the aneurism,

under local anæsthesia with ether spray. For this one always chooses the anode. The cathode of the battery is applied near the aneurism. To reduce the pain attending the operation, and to allow the current to increase and diminish gradually, one introduces into the circuit a Stöhrer's water rheostat. On inserting the needle, one makes the current as weak as possible, and then gradually increases its strength. I have applied twenty to thirty milliampères; the sittings lasted from five to ten minutes each. I have repeatedly punctured the aneurism in two places at a single sitting. I have never made use of the electro-puncture needles with two-forked points, but always a simple steel needle. If the strength of the current went above thirty milliampères, I sometimes obtained a slight eschar formation at the point of the puncture. I have always observed that during the operation the pulsation in the aneurism diminished, and that the sac contracted and felt harder. No hæmorrhage occurred, or at the most only a few drops of blood oozed out. After each sitting the patient should go to bed, and the application of an ice bag is usually found very acceptable. The efficacy of galvano-puncture consists, as is known, in bringing about coagulation at the positive pole, and in exciting contractions of the wall of the vessel.

Of other methods of treatment I will mention injections of ergotin, liquor ferri chloridi, alcohol, etc., as well as the introduction into the aneurism of foreign bodies—e. g., strands of catgut, silver, steel, and copper wire, laminaria, horse hairs, etc., to promote the formation of thrombi. As for the results of introducing steel or copper wire (filipuncture) into large aneurisms—e. g., aneurisms of the aorta—Verneuil has recently given a statistical tabulation which is very unfavourable. Of thirty-four patients thus treated, only two were cured, and thirty died comparatively soon after the operation. Philippe secured good results in experimenting upon dogs from the introduction of silver and copper wire, horse hairs, laminaria, etc., into the femoral or carotid artery. The administration of the iodide of potassium internally is highly recommended. In case of syphilis, an energetic antisyphilitic course of treatment with inunctions, etc., should be begun. Loreta, Rethers, and others, in cases of aneurism of the descending aorta, have made an incision through the skin parallel to the spinal column and over the region of the aneurism, and inserted through a small canula a piece of silver wire about one and a half metres in length into the sac. The cutaneous incision is then closed by suture.

CHAPTER XIV.

INJURIES AND DISEASES OF THE BREAST.

Malformations of the breast.—Injuries of the breast.—Inflammatory processes on the nipple and the areola.—Tumours of the nipple.—Inflammations of the breast.—Acute mastitis.—Chronic inflammations of the breast.—Tuberculosis.—Syphilis.—Milk cysts (galactoceles).—Neuralgia (mastodynia).—Hypertrophy of the breast.—Tumours of the breast.—Amputation of the breast.

§ 132. **Malformations of the Breast.**—Congenital absence of a mamma is very rare (amazia). Supernumerary mammary glands are more common (polymazia). Three, four, and five mammary glands have been observed. According to Leichtenstern, the supernumerary glands are usually found below and to the inner side of those that are normally located, less frequently in the axilla and in exceptional cases in the region of the acromion in the middle line of the abdomen, or even on the thigh. These supernumerary mammæ or separated portions of gland tissue may be the seat of tumours which have no connection with the breast proper.

Two or more nipples are sometimes found upon one mamma (polythelism).

Supernumerary mammary glands and nipples sometimes occur in male children as well as in females. At the time of puberty the mammary glands in boys occasionally secrete a colostrum-like fluid. The mammary gland in males reaches its highest development at the beginning of the twenties. Lactiferous ducts with lateral shoots and terminal vesicles are then present. Huschke has collected a considerable number of cases in which milk-secreting gland tissue had developed in males. According to Billroth, a man lived in Pavia whose breasts were eighteen inches long, and so heavy that he had them amputated. Alexander von Humboldt relates that a man in South America thirty two years old suckled his child for five months after the death of his wife.

§ 133. **Injuries of the Breast.**—Subcutaneous injuries of the mamma from a thrust, a blow, or a contusion are, as a rule, without special consequences. The subcutaneous and interglandular effusions of blood are

gradually absorbed. In girls and young married women, especially in connection with dysmenorrhœa, subcutaneous and intramammillary effusions of blood are sometimes observed without the occurrence of an injury. Traumatic influences, particularly a thrust, a blow, or a contusion, are, however, of great significance with reference to the development of carcinoma. It often happens that a blow upon the mamma becomes the determining cause of the formation of a carcinoma not only in women but also in men. A short time ago I observed a carcinoma in the breast of a man following a blow against a gate-post, which speedily recurred after extirpation and caused death, from internal metastases, about a year and a half from the beginning of the disease.

During the puerperal state, blows upon the breast not infrequently give rise to an inflammation of the mamma, attended with abscess formation (suppurative mastitis).

After burns and ulcerative processes destruction and obliteration of the nipple have occurred in rare cases.

Wounds of the breast from a cut, a puncture, or a gunshot injury are treated in conformity with general rules, as described in § 88 of the Principles of Surgery.

§ 134. **Diseases of the Nipple and the Areola.**—When there are abrasions on the nipple, ulceration easily takes place in consequence of the suckling of the child, and under certain circumstances this may lead, in consequence of microbic infection, to lymphangitis, erysipelas, and acute suppurative mastitis.

Mothers with sore nipples may be obliged to discontinue suckling their children, or at least to use protecting shields. For the soreness, cauterization with the nitrate-of-silver stick, the application of unguentum diachylon, and oxide-of-zinc powder, or wet dressings of the acetate of aluminium, aqua plumbi, glycerin, and water in equal parts, etc., are to be recommended. As a prophylactic measure the nipple should be bathed with cold water, aqua plumbi, and alcoholic fluids, for the prevention of fissures.

The suckling of children is often impossible, from the fact that the nipples are retracted or too small. Axford has successfully treated retracted nipples by operation. He excised three semilunar-shaped pieces of skin radiating from the nipple about two centimetres from the tip of the same, and then brought the fascia together at the base of the nipple by means of a purse-string catgut suture which was drawn tight.

Eczema of the nipple and the areola sometimes occurs, especially among women with unclean habits. This also leads, not infrequently,

to ulceration. The best treatment for eczema is the application of unguentum diachylon and oxide-of-zinc powder, with equal parts of starch. Glycerin and starch are also serviceable.

Syphilitic ulcers of the nipple are in part primary and in part secondary, in consequence of general syphilitic infection. Primary syphilitic ulcers, in the form of the syphilitic hard chancre, occasionally arise from suckling syphilitic children, with syphilitic ulcers on the lips or in the mouth. Secondary affections of the nipple in women who are already syphilitic consist chiefly in the development of moist, broad condylomata.

The treatment is in part local and in part constitutional (see Principles of Surgery, § 84). I should here, as in general, endeavour, in suitable cases that are brought sufficiently early under treatment, to cure the syphilitic hard chancre by removal with the galvano-cautery or the knife.

One sometimes observes thrush of the nipples among nursing women whose children are affected with thrush of the mucous membrane of the mouth (see page 366).

Tumours of the nipples are not common. Atheromata of the nipple and the areola have been observed in rare cases. Epitheliomata are no doubt most frequent, and, judging from my experience, carcinomata of the mammary glands originate much more frequently in the nipple and the areola than other authors are disposed to admit. The very frequent traumatisms and irritations to which the nipples are peculiarly exposed sufficiently explain this by no means rare development of carcinomata of the mamma from the nipple. As Paget in particular has shown, comparatively benign epithelial growths occur on the nipple, which have a very slow course and which present, as it were, the first stage of carcinoma. This stage continues a comparatively long time, as the abundant cell proliferation of the neighbouring stroma is a hindrance to the advance of the carcinoma cells. This condition is accompanied by a skin affection resembling eczema or psoriasis, which develops in the vicinity of the nipple in women from forty to sixty years old, who are otherwise healthy (Paget's disease). This skin affection is usually followed years later by carcinoma. Fully developed carcinoma runs sometimes an acute

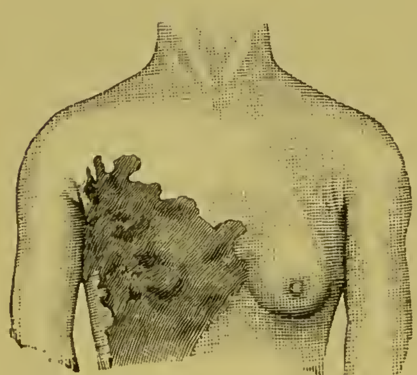


Fig. 355.—Paget's disease in a woman of fifty-two who died from a recurrent carcinoma ten years from the commencement of the disease.

and sometimes a chronic course. Psorosperms (coccidia) have been observed by several investigators, but their presence is doubted by others who look upon the bodies as degenerated cells or nuclei. According to Schulten, Paget's disease is not true carcinoma, but is closely allied to it, while Karg regards it as the first stage of carcinoma.

§ 135. **Inflammations of the Breast.**—Acute inflammation of the mamma (acute mastitis) occurs by far most frequently during the puerperium. According to Winckel, primiparæ are particularly predisposed to acute mastitis. The inflammation begins most frequently during the first four weeks after delivery, and usually arises from the microbic infection of abrasions, fissures, and ulcerations on the nipple, with transportation of the micro-organisms through the lymph passages into the breast. The microbes also spread along the lactiferous ducts of the mammary gland, and here occasion decomposition of the milk and inflammation. Erysipelas sometimes gives rise to an acute mastitis, with the formation of abscesses, in consequence of an invasion of the mamma by an enormous number of cocci (Billroth, Ehrlich). According to Legry, mastitis may also arise from suckling children with purulent conjunctivitis, and hence great caution is necessary in such cases. Acute mastitis arises not only through the lymph passages, but also from the direct entrance of micro-organisms from without into the lactiferous ducts. Mental excitement, retention of milk, and traumatisms were formerly erroneously presumed to be the causes of mastitis. Metastatic inflammations of the breast occur chiefly in the course of pyæmia following suppurative, puerperal inflammations of the uterus and its adnexa.

Non-puerperal inflammations of the mammary glands are, generally speaking, rare. They are sometimes observed during pregnancy, also in young girls at the age of puberty, in infants, and rarely also in boys and young men. Suppuration is here less common, and the course is usually subacute.

Acute mastitis is usually marked at the outset by the appearance of a circumscribed, painful swelling, particularly in the lower part of the gland. The inflammation is located chiefly in the connective tissue in the neighbourhood of the gland lobules, which abound in blood-vessels and lymphatics. The inflammatory infiltration may disappear again without the development of suppuration, but there is usually abscess formation of greater or less extent with corresponding destruction of the connective tissue that is involved, and of the neighbouring acini. The size and number of the abscesses are very variable. The inflammation and suppuration sometimes spread to the parts adjacent to the mamma, including the pectoral muscle and the periosteum of the ribs.

In rare cases foul pus containing gas is formed, depending on the nature of the microbic infection that has taken place.

Suppurative paramastitis—that is, suppuration of the cellular tissue in front of and behind the mamma between the pectoral muscle and the mammary gland—is to be distinguished from the parenchymatous suppurative mastitis just described.

The principal symptom of acute mastitis at its beginning is pain in a localized, usually somewhat indurated, spot. In severe cases the inflammation begins with a chill and high fever. The suppuration makes itself known by swelling, reddening, œdema, and finally by fluctuation. The abscesses, as has been said, are found most frequently in the parenchyma of the mammary gland, less often in front of or behind it. Very large collections of pus sometimes arise from the confluence of several abscesses. It is extremely rare for a suppurative mastitis and paramastitis to break through into the pleural cavity.

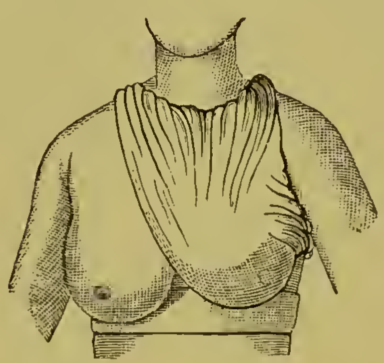


FIG. 356.—Handkerchief bandage for supporting the breast.

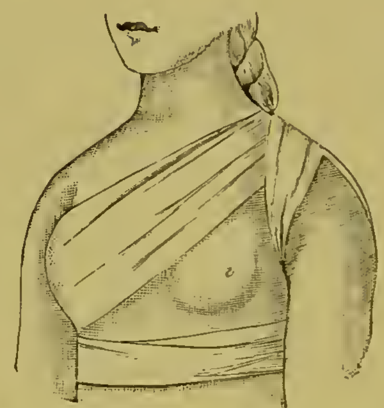


FIG. 357.—Supporting and protective bandage for the breast.

After the abscess ruptures, or is evacuated by incision, the temperature usually drops at once. In mild cases there is no suppuration, but the inflammatory infiltration is absorbed again. A subacute course is also not infrequently observed, usually terminating, however, in suppuration. The prognosis of acute mastitis is very favourable if the abscess is opened and properly drained. When the abscesses rupture spontaneously and the discharge of pus is incomplete, and fistulæ are formed, the course is usually wearisome, because relapses are constantly occurring. Large abscesses often give rise to atrophy and a corresponding deformity of the mammary gland.

The treatment of acute mastitis is at the beginning expectant. If the nursing of children is not too painful for the mother, they may be allowed to suckle from the inflamed breast. To regulate the circulation of the inflamed mamma and to prevent congestion, the breast

should be supported by a bandage (e. g., as represented in Figs. 356 and 357; see Principles of Surgery, page 189). In order to favour the absorption of the inflammatory infiltration or to hasten suppuration, wet dressings, mercurial plaster, and mild inunctions of unguentum cinereum are to be recommended. The application of ice is not always agreeable. If nursing the child is attended with too great pain, one may empty the breast by means of a breast pump, or restrict the retention of milk by cathartics.

When the existence of pus is indicated by the presence of an œdematous area or by fluctuation, a free incision should be made under local anæsthesia with ether spray or cocaine. The incisions should radiate from the middle of the gland in order to spare, as far as possible, the lactiferous ducts. In case of a severe mastitis which runs a very acute course with high fever, one should make as early as possible an incision to relieve the tension, even if there is as yet no pus. This treatment is also applicable to all cases of acute mastitis, and is superior to the use of wet dressings. By cutting into the inflamed and infiltrated area one can often prevent suppuration. One must be careful to open up all the abscesses. In case of extensive suppurations or retro-mammary abscesses it is sometimes necessary to cut through the entire thickness of the gland, under an anæsthetic, and scrape out the abscess cavity with a sharp spoon if one desires to obtain a prompt cure and avoid retention of pus. For a few days short, stout drainage-tubes are kept in the most dependent parts of the abscess cavity, and after the hæmorrhage has been arrested an antiseptic protective dressing that exerts no pressure is applied, which, as in all cases of profuse suppuration, is changed at first daily and then less frequently. Irrigation of the abscess cavity with irritating solutions is not advisable. If fistulæ result, which do not heal after cauterization with the nitrate-of-silver stick, the best way is to open them up again thoroughly, scrape them out, and drain them.

Chronic Inflammations of the Breast.—Of chronic inflammations of the mamma I mention especially chronic interstitial mastitis with the formation of nodular indurations and cicatricial contractions in women at the time of senile involution—i. e., shortly before or during the menopause. Anatomically there is a round-celled infiltration within the interstitial connective tissue of the mamma, which causes periodic pain and leads to interstitial nodular hypertrophy of the connective tissue and to progressive cicatricial contraction, so that it may be mistaken for a new growth. As a matter of fact, we really have to do sometimes in such cases with carcinoma, usually in the form of a scirrhus (see page 736, Carcinoma of the Mamma). Suppuration never occurs. The process finally comes to a standstill, and the nodular indurations may gradually and wholly disappear again.

The best treatment of chronic interstitial mastitis, if any is needed, is the inunction of mercurial ointment and the application of rubber bandages so as to obtain pressure, or of cotton and gauze bandages, the outer layers of which are filled with water glass. The latter dressing is allowed to remain in place from three to four weeks. Verneuil, Phocas, and others recommend for this chronic mastitis occurring shortly before or in the menopause the use of a carbolic spray, which is said to act, as it were, like massage. If the pain is severe, the best treatment is to amputate the breast, especially as the chronic inflammation sometimes favours the development of a carcinoma. In fact, it is often difficult to decide whether we have to deal with a carcinoma or not.

König has described another fairly common form of chronic mastitis, which stands on the border line, as it were, between inflammatory processes and tumours, and leads to the formation of cysts varying in size. This mastitis chronica cystica—which Schimmelbush erroneously described as an adeno-cystoma—occurs at any age after puberty and often involves both breasts. We have to do histologically with an inflammatory process which attacks the parenchyma as well as the interstitial connective tissue. The cells of the gland tissue proliferate and then degenerate, giving rise to cavities or cysts containing an aqueous or mucous fluid of a dark colour. The interstitial connective tissue is swollen, contains many nuclei, and is infiltrated with leucocytes. This form of mastitis is usually painful; the breasts enlarge, especially at the time of menstruation, and then grow smaller again. The further course is characterized by the appearance of numerous hard indurated tumours and various-sized cystic nodules. One can isolate with the thumb and finger the soft, round, fluctuating nodules or cysts from the rest of the breast, but they disappear, as it were, within the breast when one presses the latter with the palm of the hand against the chest wall. The cysts vary in size, but are never larger than a pigeon's egg. The diagnosis is frequently difficult, and the breast is often amputated erroneously or at the request of the patient when it is not at all necessary. The treatment is mainly symptomatic.

Tuberculosis of the Mamma.—Tuberculosis of the mamma (W. Roux, G. Mandry, E. Bender, and others) is rare. It is characterized by the formation of numerous grayish-white tubercles or of caseous nodules the size, for example, of a hazelnut or a walnut; also by the appearance of cold abscesses; and, above all, by the presence of tubercle bacilli. The tubercular foci are found in the vicinity of the lobules of the gland as well as in the neighbourhood of the excretory ducts. In the main, two forms of tuberculosis of the mammary gland may be distinguished aside from the cold abscesses. These are the confluent and the disseminated form (Piskaček, W. Roux). Tuberculosis is usually secondary, being caused either by metastasis or by the extension of a tubercular process in the adjacent parts. The treatment should consist in opening and scraping out the tubercular foci and in building up the strength of the patient, as described in Principles of Surgery, § 83. In the disseminated form, early amputation of the mamma, with removal of the axillary contents, is indicated. In case of isolated tubercular disease of the mamma without tuberculosis of other organs the prognosis is favourable.

Syphilis only rarely becomes localized in the breast as a gummatous mastitis and as circumscribed gummata in the later stages of the disease (Hennig). We have already mentioned primary and secondary syphilitic ulcers of the nipple (page 728). In addition to proper local treatment, antisyphilitic measures should always be adopted (see Principles of Surgery, § 84).

The formation of lime concretions has repeatedly been observed in the mamma—e. g., from calcification of tubercular foci or of fibrous thickenings; also in obliterated gland ducts (Ackermann), in cysts and cyst walls, in connection with gout, etc. Such calcifications or concretions scarcely give occasion for treatment.

Milk Cysts (**Galactoceles**).—Cysts due to the retention of milk, which are not common, arise usually from the obliteration or obstruction of an excretory duct from one portion of the mammary gland. They form distinctly fluctuating tumours, sometimes of considerable size. Walpy, for instance, drew five kilogrammes of milk from a cyst of this kind by puncture. Scarpa observed a milk cyst in a woman twenty years old after her second confinement which reached down to the thigh and, when tapped, discharged ten quarts of pure milk. The retained milk is sometimes transformed into a caseous, butterlike, or oil-like mass. According to Küstner, a milk cyst may cause the surrounding tissue, partly by pressure and partly by chemical processes, to become more or less liquefied. If a galactocele ruptures subcutaneously, the cellular tissue becomes diffusely infiltrated with milk (Velpeau). The treatment of milk cysts consists in emptying them by puncture, or, better, by incision and drainage.

Neuralgia of the Breast (**Mastodynia**).—Not infrequently severe pains are felt in one or, less often, both breasts, which recur periodically and are most severe at the beginning of menstruation. The pains are located in the tissue of the mamma, but the cutaneous covering of the breast is also very sensitive sometimes, especially on pressure. Abnormalities proper are either absent altogether or one feels, more or less distinctly, uneven indurated areas or circumscribed nodules in the mamma about the size of a hazelnut or a walnut. The latter are not cases of neuralgia proper, but we have here to do either with chronic interstitial mastitis, with adenoma formation, or, not infrequently, with neurofibromata. Neuralgia proper is observed particularly in nervous, hysterical women with diseases of the genital organs. In a portion of the cases we have to deal, no doubt, with intercostal neuralgia.

The treatment of mastodynia is directed chiefly against the cause, especially any disease of the genital organs that may be present, hysteria, etc. The success of local treatment is usually uncertain. It consists in the application of ice or wet compresses, and in supporting the breast and avoiding all compression. The latter is sometimes, on the contrary, very beneficial. The inunction of lanolin with mercurial ointment or with belladonna is very serviceable. Quinine, arsenic, and calomel internally, life in climatic health resorts, etc., are useful. If the so-called tubercula dolorosa are present—that is, neurofibromata—their extirpation is to be recommended.

Hypertrophy of the Breasts.—Hypertrophy of the breasts is due to an increase in the normal-tissue elements. It is usually observed in girls from fourteen to sixteen years of age and in young married women. The more marked cases of hypertrophy, which always affects both breasts, are rare.

According to Billroth, the development of hypertrophy of the mamma is usually very rapid, occupying, for example, from two to four months. It then, as a rule, remains stationary or begins again temporarily at the time of pregnancy. A continuous increase in the size of the breasts does not occur. In rare cases the hypertrophy of the mamma is so great that the ability to work and the nutrition of such women are interfered with. Hypertrophied breasts sometimes reach as far as the anterior superior spine of the ilium. As has been said, we have to do anatomically in this condition with a simple hypertrophy of the tissue of the mamma—that is, of the connective tissue and the gland substance. All those cases in which the increase in the size of the breast is conditioned upon new growths, such as adeno-fibromata or other tumours, do not belong here, of course, but are to be classed with neoplasms. The treatment of hypertrophy of the breast consists in amputation of the mamma in case there is much discomfort. Other remedies (compression, iodide of potassium, etc.) are ineffectual.

§ 136. **Tumours of the Breast.**—Of the epithelial tumours of the mamma, I mention first the adenoma, or, more accurately, adeno-fibroma, because, in addition to the proliferation of the gland substance, there also occurs more or less hypertrophy of the interstitial connective tissue. The adenoma (see Fig. 358) and adeno-fibroma resemble most of all the above-mentioned hypertrophy of the breasts, the only difference being that in the latter case a diffuse, general, and bilateral hypertrophy of the tissue of the mamma takes place, while in the former there is a circumscribed and unilateral new growth of tissue in the form of nodules. Adenomata form, as it were, the first stage of carcinomata. In the adenoma an increased growth of gland cells takes place within the limiting membrane of the gland ducts and lobules. If, however, the epithelial proliferation breaks through the limiting gland membrane and goes on at random in the connective-tissue stroma the adenoma has become a carcinoma. The early stage of the transformation of the adenoma into a carcinoma is also called adenoid. Adenomata usually grow slowly, are commonly not larger than an apple, and form, as a rule, roundish, hard, uneven, easily movable nodules which do not adhere to the skin. In rare cases adenomata, in consequence of suppurative inflammation and abscess formation in their neighbourhood, become necrotic, so that they can be extracted without difficulty. Adenomata of the mamma are benign tumours. They never

Fig. 358.—Alveolar adenoma of the mammary gland. × 30.

form metastases and never lead to infection of the lymph glands in the axilla. Malignant, destructive adenomata, with metastases and infection of the neighbouring lymph glands, such as occur in the rectum, are practically never seen. The serious thing about adenomata is that they may finally change into carcinomata. Adenomata sometimes cause severe neuralgic pain. Aside from the combination of the adenoma with fibroma (adeno-fibroma), there are various other mixed forms, especially adeno-myxoma—that is, adenoma with myxomatous interstitial tissue; and adeno-cystoma—that is, adenoma with cyst formation, which has been described by Thiersch, the author, and others. The cysts here arise from degeneration of the newly formed acini, which is always of favourable prognostic significance for the patient. Many forms, however, of adeno-cystomata may easily become malignant by spreading along the lymph vessels. The lymph vessels near the dilated acini have been found filled with epithelial cells (Reclus, Brissaud, Pilliet). Adeno-fibromata and adeno-cystomata sometimes reach a large size.

Aside from the cysts formed in adenomata, sarcomata, and fibromata, single or multiple cysts are also observed in the mamma not combined with other forms of tumour (Bryant). These cysts, which usually have a slow growth, are really retention cysts, and they arise from dilatation of the lactiferous ducts or the acini, and mainly, according to Billroth, of the small excretory ducts. Papillary excrescences are sometimes found as remains of the earlier septa. The cysts seldom develop before the fortieth year, are altogether painless, and usually attain at most the size of an orange. The contents of the cysts consist usually of a mucous or serous fluid, which is either colourless or greenish brown. In rare cases the contents resemble butter, or oil, or cream—that is, we have to do with galactoceles (see page 733). From calcification of the contents of the cysts and of their walls mortarlike formations result. The so-called proliferating cysts arise mostly from proliferation of epithelium and are usually adeno-cystomata, less often cysto-sarcomata. Adeno-cystomata are usually smaller than cysto-sarcomata, which may attain a large size. The diagnosis of cysts can not always be made with certainty. Fluctuation, particularly in the case of fleshy individuals, is not easy to make out, and it is therefore not surprising that the cysts are not infrequently mistaken for carcinoma nodules, adenomata, or adeno-fibromata.

On the border line between inflammatory processes and tumours we have the comparatively frequent mastitis chronica cystica, which leads to the formation of multiple cysts varying in size (see page 732).

Billroth observed a very large cholesteatoma, the size of a duck's

egg, which started either in a lobule of the mammary gland or in a deeply situated sebaceous gland. Cholesteatomata are partly atheromata and partly dermoid cysts, with characteristic, often silklike, contents, which consist of fat, cholesterine, and masses of cells which shine like mother-of-pearl. According to Eppinger, Chiari, and Eberth, cholesteatomata are really endotheliomata, which arise from proliferation of the endothelia of the vessels or of the cells of their surrounding sheath.

Atheromata sometimes arise from obstruction of the outlet of sebaceous glands of the skin, and grow into the mamma.

Carcinoma of the Breast.—Carcinoma is the most common of all tumours of the mammary gland. It constitutes, according to Gross, 82·47 per cent, according to Bryant 83·16 per cent, and according to Billroth eighty-five per cent of all tumours of the mammary gland in women. The carcinoma occurs especially in women from forty to forty-five or fifty-five years of age. It is much less common among men. According to Schulthess, the age curve of carcinoma patients reaches its highest point between the forty-fifth and the forty-ninth year, the beginning of the menopause. Winiwarter finds this point for Vienna to be between the forty-first and the forty-fifth year. According to Fink, the average age of two hundred and fifty-three patients with carcinoma of the breast in Gussenbauer's clinic was fifty-one and six tenths years, while Sprengel found the average age to be fifty and four tenths years. According to Schulthess, one out of every hundred women of the right age for carcinoma succumbs to the disease. Carcinoma of the mamma is usually unilateral, both mammary glands becoming but seldom involved either simultaneously or in succession. Carcinoma of the breast begins, as a rule, as a painless, circumscribed hardening, or as a hard nodule, incorporated in the gland substance, which is very often discovered by the patient only by accident. Women not infrequently have their attention drawn to the nodule by lancinating pains. The growth of a carcinoma is very variable, being sometimes rapid and sometimes slower.

Anatomically, the following forms of carcinoma of the mammary gland are distinguished:

1. The acinous carcinoma (Billroth), which, on gross inspection, usually consists of grayish-white or reddish-gray nodules varying in consistence. The acinous carcinoma is the softest form of carcinoma of the mammary gland. Sometimes very soft medullary nodules are observed. The stroma is usually thoroughly permeated by round cells, and here the carcinoma proper is found in the form of masses of epithelial cells, which in a general way resemble acinous glands. The acinous carcinoma is strongly inclined to softening, breaking through the skin and ulceration. Metastases usually

soon appear in the axillary glands, which have the same structure as the primary tumour.

2. The most frequent form of carcinoma of the breast is the carcinoma simplex, a tubular carcinoma, which takes the form more of a carcinomatous infiltration, and usually involves the skin very early, forming multiple nodules or a diffuse infiltration. The cancerous cell nests in the carcinoma simplex are, as a rule, smaller. They often form long, tubelike (tubular), or more irregular masses of epithelial cells. The carcinoma simplex spreads by choice along the surface, and may permeate the whole gland. One often finds a rather rapid, non-continuous extension of the infiltrations and nodules of the carcinoma to the skin, the subcutaneous cellular tissue, the ribs, the sternum, and the pleura. Very numerous nodules and hard, diffuse infiltrations are sometimes found in the skin, so that the latter feels as solid as leather, giving rise in some cases to the so-called *cancer en cuirasse.* Not infrequently ulceration occurs. As in the acinous carcinoma, degenerative changes take place in the cells of the tumour, particularly fatty degeneration.

Fig. 359.—Carcinoma simplex of the mammary gland. × 200.

3. The scirrhus is comparatively poor in cells, and usually grows slowly. It is characterized by cicatricial contraction of the stroma, with disappearance of the carcinoma cells, hand in hand with which, however, a proliferation of epithelial cells takes place. Scirrhus may also take the form, clinically, of so-called *cancer en cuirasse.*

4. The colloid carcinoma (carcinoma gelatinosum) arises from colloid degeneration of the carcinoma cells, so that the alveoli are filled with colloid material. In other respects the colloid carcinoma presents the structure of the carcinoma simplex. According to Klebs, the colloid material is secreted from the carcinoma cells; according to Doutrelepont and Rindfleisch, from the vessels. It is usually found between the carcinoma cells and the inner wall of the connective-tissue alveoli—that is, the cells are surrounded by a clear, homogeneous colloid layer.

Neugebauer, in Wölfler's clinic, described a case of carcinoma psammosum of the female breast—i. e., an adeno-carcinoma with calcareous degeneration of the epithelial cells and corresponding formation of sand. The sand was first discovered by microscopic examination, and not only in the mammary tumour but also in the infected axillary glands. This form of carcinoma had previously been found only in the ovaries.

A chondro-osteocarcinoma of the mamma has been described by Heurtoux, Hacker, and Coen.

On gross examination, all carcinomata of the mammary gland present upon section a reddish-gray or grayish-white appearance, and their alveolar structure is plainly visible—that is, one sees pale, firm bands of connective

tissue, which cross each other, forming a network with softer tissue inserted, the latter being the alveoli. A turbid juice containing small granules may be scraped off with a knife from the surface of the cross-section. This material consists, microscopically, of detritus, and especially of carcinoma cells, either single or massed together into spherical or cylindrical forms. These cells are usually large, round, or angular, resembling epithelia, and are provided with a large nucleus and shining nucleoli. The carcinoma cells lie in groups in a vascular, connective-tissue stroma permeated by round cells. They are derived from the glandular epithelium, or originate, when the proliferating process begins, in the skin, from cells of the rete Malpighi, the hair follicles, or the follicular and sweat glands. The development of carcinoma from epithelial proliferation can always be best recognised in the mamma and the skin by the microscopic examination of sections taken near the limit of the tumour. One sees here, beside the normal tissue of the mamma, hypertrophy of the gland substance—i. e., adenomatous proliferation with a well-marked acinous arrangement. In the more advanced portions the proliferated epithelial cells have broken through the limiting membrane of the gland and begun to spread in the neighbouring connective tissue. In the oldest zones representing the real carcinoma one then sees a more irregular proliferation of the epithelial cells in the form of single groups of cells in a connective-tissue stroma richly supplied with vessels and cells.

In addition to this growth of epithelial cells one observes that the connective-tissue stroma is in a condition of active cell proliferation, there is a small-celled infiltration of the same, and the vessels are multiplied. The proliferation of the epithelial and connective-tissue elements go, as it were, hand in hand, or, more accurately, there breaks out a sort of border warfare between the epithelial cells and the connective tissue, which in carcinoma always ends in the victorious advance of the epithelial cells (Thiersch, Waldeyer).

All carcinomata become the seat of retrogressive changes, especially fatty degeneration of the epithelial cells as well as of the stroma. Hence the skin becomes perforated, craterlike ulcers are formed, and cicatricial contraction of the stroma takes place, with retraction of the skin and the nipple. This cicatricial contraction is most pronounced, as has been said, in the scirrhus. The tissue is here sometimes so hard that it grates under the knife. A portion of the carcinoma may disappear in consequence of the retrogressive metamorphosis and the cicatricial contraction, but it has never yet been found that a complete cure can result in this way. A rapid, fatty degeneration of the carcinoma cells may arise also from infection by micro-organisms—e. g., pus cocci and erysipelas cocci (see Principles of Surgery, § 71, page 346). In ulcerating carcinomata that have broken through the skin the greatest variety of micro-organisms are found, including mould fungi. Regarding the significance of micro-organisms in connection with carcinomata, see Principles of Surgery, page 779.

Carcinomata spread in part continuously and in part non-continuously. They penetrate the muscles, the pleura, the lungs, the ribs, and the sternum. The carcinoma cells make their way along the tissue clefts, and are transported through the blood and lymph channels, especially the latter. Hence there follows carcinomatous infiltration of the neighbouring lymph glands

in the axilla, in the infraclavicular and supraclavicular fossa, etc. In carcinoma of one breast one finds in rare cases that the axillary glands on both sides are involved, and it also happens, exceptionally, that the lymph glands on the opposite side are alone affected (Volkmann). The enlargement of the lymph glands sometimes disappears again, in which case it was simply of an inflammatory, not of a carcinomatous nature (Winiwarter). The carcinomatous infection then constantly advances from the lymph glands. Metastases appear in the internal organs (pleura, lungs, brain, spleen, liver, bones, etc.), and the patient dies of cancerous cachexia. Among seven hundred and thirty-three cases of carcinoma of the breast the autopsy showed, according to Paget, metastases two hundred and forty-one times in the liver, thirty times in the kidneys and suprarenal capsules, while the spleen was involved seventeen times, the ovaries thirty-seven times, etc. Metastases are not infrequently found also in the osseous system—e. g., according to Paget, out of six hundred and fifty cases, eighteen times in the femur, ten times in the humerus, thirty-six times in the skull. Carcinomatous pleurisy arises most frequently from continuous extension of the carcinoma through the soft parts of the chest. Very small tubercles and nodules are formed at first, and then, finally, nodules the size of a hazelnut or walnut or even of an apple. The lungs are generally involved secondarily from the pleura in consequence of continuous extension of the process.

According to Winiwarter, carcinoma develops most frequently between the forty-first and the forty-fifth year. All carcinomata occurring before the thirtieth year attacked married women, according to Billroth. Carcinoma of the breast is much less common in men. The frequent variations in the physiological condition of the mamma during menstruation, pregnancy, lactation, and later at the beginning of the menopause, are of importance in the development of carcinoma in women. Injuries of the most varied character—e. g., thrust, blow, pressure of corsets, etc., as well as inflammations of the skin and of the mamma (eczema, acute mastitis, chronic interstitial mastitis)—not infrequently constitute the determining cause. Of one hundred and fourteen patients with carcinoma of the mamma, twenty-four, according to Winiwarter, had had acute mastitis. Carcinomata following acute mastitis occurring during lactation usually have a very speedy fatal termination. Among one hundred and seventy cases of carcinoma of the mamma, there were only twelve, according to Winiwarter, in which there had been an injury. In ten cases there was an inherited predisposition. The favourite place for the commencement of carcinoma of the mamma is, according to H. Schulthess, the upper, outer quadrant, and not infrequently the nipple and the areola. The affection of the nipple and its areola (see page 728), described by Paget, presents, no doubt, the mildest form of carcinoma, or rather its first stage (Karg).

The clinical course of carcinoma of the mamma is very varied. Its duration from its commencement to its fatal termination is, generally speaking, between one and a half and two and a half years. According to Fink, who tabulated two hundred and fifty-three cases of carcinoma of the breast in Gussenbauer's clinic (1878–1888), the average duration of life after the beginning of the disease is for those operated

upon twenty-seven and four tenths months, and for those not operated upon twenty and five tenths months; so that according to this computation life was only prolonged upon the average seven months by the operation. One sometimes observes a very rapid course, so that even at the end of six months death ensues from internal metastases. In other non-malignant cases the disease lasts five, ten, or twenty years. According to Billroth, the duration varies from six months to twenty years. Soft carcinomata, with large nodules and the *cancers en cuirasse* (Fig. 360), have the most unfavourable and the most rapid course. That of colloid carcinoma and scirrhus is more favourable. Doutrelepont, for example, observed a colloid carcinoma of thirteen years' standing.

Fig. 360.—Ulcerating carcinoma of the breast in a woman of forty-three with numerous nodules in the surrounding skin and marked induration of the cutis (*cancer en cuirasse*).

The axillary glands become involved, according to Billroth, from fourteen to eighteen months, generally speaking, after the beginning of the disease in the mammary gland. The appearance of internal metastases is very variable. We have upon this point but little exact and certain knowledge. The autopsy has sometimes revealed internal metastases from six to nine months after the discovery of the primary nodule.

A spontaneous cure of carcinoma of the breast does not occur. The only possible cure is by prompt extirpation of the mammary gland and the regionary lymph glands, as well as the cellular tissue in the axilla. There is more hope of cure from the operation if there is no involvement of the axillary lymph glands. If at the time of the operation the glands in the axilla or in the supraclavicular or the infraclavicular fossa are already involved, death from recurrence ensues, according to Winiwarter, thirteen months on the average after the operation. If the axillary glands are unaffected at the time of the operation, the patient usually lives, according to Winiwarter, about twenty-two months, and the entire duration of the disease is prolonged by the operation to about fifty months on the average. Permanent cure is possible from early removal of the diseased breast and axillary contents. If recurrence has appeared neither at the place of operation on the mamma nor in the axillary glands within one year after the performance of the operation, there is prospect of a complete cure. If three years pass without recurrence, a permanent cure is assured almost

without exception. Still, recurrences have been observed in exceptional cases after from four to eleven years (Küster, Hans Schmidt, the author). In such cases we have really to do with a new tumour (regionary recurrence). In rare cases a permanent cure results only after the second or even after the third operation for recurrence. The number of cures, however, is very small in comparison with the great number of cases of carcinoma of the breast. One recurrence usually follows another. The recurrences are either continuous at the place of operation, if carcinoma tissue has been left behind, or regionary in consequence of renewed carcinoma growth in the cicatrix or in the immediate vicinity independent of the first tumour. Winiwarter also distinguishes infection recurrences and metastatic recurrences resulting from metastases in the axillary glands and in the internal organs. Infection recurrences take place when before the operation carcinoma germs had become lodged in the axillary glands, but their presence was not then demonstrable.

Permanent cures have been decidedly more frequent during the last ten years, as is shown by various statistics—those, for example, of Gross, Rotter, Hans Schmidt, Fink, and others. This is the result of the more thorough method of operating with clearing out of the axilla. The percentage of permanent cures—the patient remaining well more than three years—varies very much according to the different statistical tabulations (Winiwarter 4·7 per cent, Henry 9 per cent, Sprengel 11 per cent, Oldekop 11·7 per cent, Rotter 12·1 per cent, Fink [Gussenbauer's clinic] 16·7 per cent, Hans Schmidt 21·5 per cent, Hildebrand 22·5 per cent, etc.).

Death follows partly in consequence of the local extension of the mammary carcinoma to the pleura and the lungs, partly from metastases with increasing exhaustion ; also from hæmorrhages, septic infection in consequence of sloughing carcinomata, etc. Carcinomatous pleurisy is the most frequent cause of death. Those patients suffer the most pain in whom the carcinoma of the breast has caused metastases in the vertebræ. Patients not infrequently die of internal metastases without local or regionary recurrence. According to my experience, the most unfavourable carcinomata, sometimes leading to a very speedy fatal termination, are those which develop in younger women subsequent to mastitis from lactation. The prognosis of carcinoma of the breast seems, generally speaking, to be the more unfavourable the younger the patient is.

For the diagnosis of carcinoma of the mamma the following is of importance : It is usually a hard, nodular tumour which occurs most frequently in women over forty years of age, and which usually develops gradually and

without pain. Carcinoma nodules are not movable within the breast, and they finally become adherent to the skin. Retraction of the nipple, and especially the presence of indolent, hard, enlarged lymphatic glands in the axilla, are particularly characteristic of carcinoma.

Lobulated, uneven, hard nodules occurring from the time of puberty until the thirtieth year, with a slow growth, are mostly fibromata or adeno-fibromata. Very rapidly growing soft tumours in girls and women are usually extremely malignant medullary sarcomata. Very large tumours are chiefly cysto-fibromata, cysto-sarcomata, or cysto-adenomata. They likewise occur most commonly in younger women. Superficially located cysts can usually be easily diagnosed, whereas those that are more deeply seated in the tissue of the mamma are not infrequently mistaken for carcinomata. The same is true of deeply seated tubercular or syphilitic foci, for which, however, the condition of the patient in other respects affords important clews—e. g., tuberculosis of the lungs or other organs, other syphilitic affections, the history of the case, etc.

The treatment of carcinoma of the breast consists in the earliest possible removal of the mamma. Even if no enlargement of the axillary glands is demonstrable by palpation, still the axilla should always be laid open from the operation wound and all the cellular tissue and lymphatic glands should be removed. Special attention must be paid in doing this to the space between the pectoralis major and minor muscles. If the underlying muscle is already involved it must be in great part or wholly removed. Even if the pectoral muscle is not yet involved, one should always cut away the fascia and a superficial layer of the muscle. In short, the extirpation of the mammary gland when affected by carcinomatous disease should be performed with all possible thoroughness (for particulars, see page 746, Technique of Amputation of the Breast).

Nussbaum has recently expressed himself in favour of extirpation of carcinoma of the breast by means of the thermo-cautery. It is thought that in consequence of the more marked wound reaction, the suppuration, and the solid cicatrix, recurrences are not as frequent after operating in this way as after extirpation with the knife, in which the wound heals aseptically and without reaction. On the same grounds Bougard has recently again recommended cauterization with chloride-of-zinc paste or the caustic point (see Principles of Surgery, pages 79 and 80). I prefer to remove slight recurrences by the galvano-cautery or the thermo-cautery, and am extremely pleased with the results.

The treatment of inoperable carcinomata of the mamma is symptomatic. One can try various other methods of treatment according to the nature of the case, especially the use of parenchymatous injections of absolute alcohol, tincture of iodine, ergotin, acetic acid, nitrate of

silver, arsenic, turpentine, hyperosmic acid, phosphorus, pyoktanin, etc. Turpentine is injected, according to Vogt's plan, with absolute alcohol in equal parts or one part turpentine to two parts alcohol, about half or an entire hypodermic syringeful in from ten to fourteen days. There usually ensues at the end of this time abscess formation with more or less contraction of the tumour. Of the hyperosmic acid, about three drops of a one-per-cent solution are injected daily (Winiwarter). Pyoktanin (methyl violet) was recommended by Mosetig-Moorhof (1 : 300–500 aq. dest., one or two hypodermic syringefuls or more, according to the nature of the case, about twice a week). Arsenic may be given internally and injected subcutaneously in the form of Fowler's solution. One gives at first ten drops a day internally and then increases the dose about two drops every third day. One injects into the tumour about two drops daily or ten drops once a week of the undiluted Fowler's solution. If the patient is especially sensitive to arsenic, the solution is diluted in the proportion of one to two or three. Finally, erysipelas has been inoculated in the form of cultures of the erysipelas coccus into inoperable carcinomata of the mamma, and Janicke and Neisser have observed that in consequence the carcinoma cells are destroyed by fatty degeneration. W. Busch, as is known, was the first to find that sarcomata of the face and the neck completely disappeared by fatty degeneration after erysipelas. One must always bear in mind, however, before inoculating erysipelas, that this also may terminate fatally, as, for example, in the case of Janicke and Neisser which was just mentioned. In case of sloughing carcinomata one can reduce the pain and the sloughing by scraping with the sharp spoon, by use of the thermo-cautery, by means of deodorizing dressings of acetate of aluminium, naphthalene, iodoform, etc. I have sometimes seen very favourable effects produced by circular cauterization of the area with the thermo-cautery in cases of inoperable carcinomata. The pain and the sloughing were diminished to a marked degree and the carcinoma underwent marked contraction. Frequent hypodermic injections of morphine will be necessary in treating inoperable carcinomata. Esmarch, Beneke, and Van Den Corput have also recommended for patients with carcinoma a diet containing but little nitrogen.

Other Tumours of the Breast.—The greatest variety of tumours of the connective-tissue type has been observed in the breast, especially fibromata, sarcomata, cysto-sarcomata, lipomata, and, less frequently, chondromata and osteomata, angeiomata and neuromata.

Fibromata are sometimes pure, sometimes in combination with adenomata, sarcomata, myxomata, and cysts, in the form of fibro-adenomata, fibro-sarcomata, fibro-myxomata, and fibro-cystomata. Fi-

bromata develop mainly from proliferation of the connective tissue surrounding the acini and the small excretory ducts (pericanalicular fibroma). They are most frequent in young persons from seventeen to thirty years of age, and very rare beyond the fortieth year. Unmarried and barren women seem to be especially predisposed to them. Pure fibromata usually form uneven, solid nodules of about the size of a walnut or a hen's egg, which, as opposed to carcinomata, are freely movable within the breast. In exceptional cases, especially when combined with a cystoma, fibromata attain a considerable size. Fibro-adenomata, as well as fibromata, are sometimes multiple, do not form metastases, and do not recur. Schimmelbusch classifies cysto-sarcoma phyllodes (Müller), myxoma intracanaliculare (Virchow), and serocystic sarcoma (Brodie), all of which tumours may attain an enormous size among the benign fibro-adenomata, and thinks they should be distinguished from the true cystic sarcomata.

Pure myxomata of the mamma are very rare. The fibro-myxomata, which have been already mentioned, are more common.

The various forms of sarcoma all occur in the mamma—viz., round-celled, spindle-celled, small-celled, large-celled (Fig. 361), and giant-celled sarcomata, angeio-sarcomata, lympho-sarcomata, alveolar sarcomata, melano-sarcomata, and soft medullary sarcomata. The last two are, as is known, the most malignant varieties. According to Gross, who has collected one hundred and fifty-six cases of sarcoma of the mamma, sixty-eight per cent of these were spindle-celled, twenty-seven per cent were round-celled, and five per cent were giant-celled. The angeio-sarcoma, which has been described in detail by the author and G. B. Schmidt, is not very rare. It can easily be mistaken for carcinoma. Sarcomata originate in the periacinous and pericanalicular connective tissne, and above all in the walls of the blood-vessels, as I have shown more in detail in a very characteristic case. Billroth observed a medullary round-celled sarcoma with striated muscular fibres which had probably developed from strayed muscle germs of the pectoral muscle. Sarcomata are often permeated by dilated gland ducts and cysts. Cysto-sarcomata not infrequently attain a large size. Cauliflower-like proliferations are sometimes found in consequence of growth of the periglandular connective tissue into the above-mentioned gland ducts and alveoli (sarcoma phyl-

FIG. 361.—Large-celled sarcoma of the mammary gland. × 300.

lodes, cysto-sarcoma proliferum, intracanalicular fibroma, or sarcoma). Sarcomata occur at all ages. They usually grow slowly at first, and then, especially the soft sarcomata which contain many cells, very rapidly. The least malignant are the cysto-sarcomata, the most malignant being the melano-sarcomata and soft (medullary) round-celled sarcomata. The spindle-celled and the cystic sarcomata are found, as a rule, according to Gross, at an early age, while the mamma still performs its function. The average age of the patients in one hundred and forty-eight cases was thirty-six years and seven months. The average age of patients with round-celled and giant-celled sarcomata was forty-seven years and three months. These develop at the time of physiological retrogressive changes in the mamma. Of fifteen sarcomata in patients under twenty years of age, fourteen were of the spindle-celled variety.

Gross has established the following facts in regard to the permanent cure of sarcoma, based upon ninety-two cases: Twelve patients remained well four years or longer; forty-two had local recurrence, most of them (57·7 per cent) within six months, on the average at the end of ten months and a half, in some cases after from one to four years. The tumours in young persons and those in whom the function of the gland is active, showed a pronounced tendency to recur and less to form metastases, while the reverse was true in sarcoma of a mamma that was undergoing involution. As compared with carcinoma of the mamma, the sarcoma inclines more to metastases and less to local recurrence. The lymphatic glands are affected much more frequently (67·4 per cent) in carcinoma than in sarcoma (0·64 per cent). According to Gross, the average duration of sarcoma is eighty-one months, and that of carcinoma only thirty-nine months, permanent cures of the former amounting to 13·2 per cent, and those of carcinoma to only 10·4 per cent.

Chondromata and osteomata of the mamma are very rare (Leser). According to Billroth, they are rather frequent in dogs of the female sex. They must not be confounded with calcification—e. g., of cyst contents and cyst walls. Cartilaginous tissue and bone tissue are occasionally found in a great variety of tumours of the mamma (Hacker).

In very rare cases lipomata, angeiomata, and neuromata have been observed in the mamma. Lipomata are more frequently found behind the mamma or alongside it. Astley Cooper and Billroth have seen enormous lipomata behind the mamma which pushed the gland substance before them. In Astley Cooper's case the tumour weighed more than seven kilogrammes.

Angeiomata and neuromata sometimes begin in the skin and invade the mamma secondarily.

Finally, echinococcus cysts of the mamma are very rare. Their diagno-

sis depends especially upon the detection by means of the microscope of booklets and shreds of membrane in the cyst contents obtained by a trial puncture.

The treatment of tumours of the breast conforms to generally accepted rules as we have described them above (page 742) for carcinoma, as well as in Principles of Surgery, §§ 127 to 130, for the different varieties of tumours.

Tumours of the mammary gland in males are, generally speaking, rare. According to Billroth, no case of fibroma, cysto-sarcoma, or adenoma has as yet been described in literature. Poirier and Horteloup observed tuberculosis in the male mammary gland. Cysts of the mamma have been found repeatedly among older men. Carcinoma of the male breast is the most common. Billroth saw seven cases and the author has seen five. Schuchardt has collected four hundred and sixty-nine cases of tumours of the male breast. Among them were three hundred and ninety-one malignant tumours (sarcomata and carcinomata), the large majority being carcinomata. According to R. Williams, there is one case of carcinoma of the male breast to about one hundred of the female breast. The acinous form of carcinoma is the most common. Cancroids of the areola are sometimes found in men, not a single case of which was observed, according to Williams, among 2,422 tumours of the female breast. In single cases melano-sarcomata have occurred in the male mammary gland. The patients are mostly from fifty-five to sixty-five years of age. An exceptional case of a patient twenty years old was observed. Traumatisms, chronic eczema of the areola of the nipple, and inherited tendency are of importance etiologically. The course of carcinoma in the mammary gland of males is essentially the same as among women. Cases leading to a speedy fatal termination are by no means rare. Treatment here also consists, of course, in the earliest possible removal of the breast and axillary contents.

§ 137. **The Technique of Amputation of the Breast.**—Amputation of the breast is performed chiefly for malignant tumours, and is always in this case to be combined with opening the axilla and removing all the lymphatic glands to be found there, together with the adipose and cellular tissue, even though no enlarged lymph glands are to be felt externally. Only benign tumours should be removed from the mammary gland with preservation of the latter.

Every patient who is to undergo an amputation of the breast must take a full bath beforehand, and be thoroughly cleaned with soap. The field of operation, including the front of the chest, the axilla, the shoulder, and the back, is then rubbed with ether and scrubbed with 1-to-1,000 bichloride. The body should lie as flat as possible, with the shoulder upon the diseased side slightly elevated. The arm on the diseased side is drawn upward and outward by means of a sling, so as to secure sufficient access to the axilla, which is to be opened later.

The neighbourhood of the field of operation is covered with aseptic mull which has been moistened in 1-to-1,000 bichloride. For sponging the wound, it is better to use aseptic gauze pads instead of sponges. If there is a sufficient amount of sound skin for covering the wound later, one cuts around the nipple by means of two curved incisions made in such a way that, after extirpation of the mamma, the incision can be prolonged from one angle of the ellipse to the axilla (see Fig. 362). The skin is now dissected up from the subjacent parts along the upper curved incision as far as the border of the mamma, and one then cuts down to the pectoral muscle and detaches the breast bluntly with the fingers. This blunt detachment of the mamma from the subjacent parts has the great advantages that the hæmorrhage is very slight, and that one feels any adhesions that may exist between the carcinoma and the pectoral muscle. If the muscle proves to be affected, the parts of it that are involved, or the whole of it, must be excised. The mamma is now attached only to the adipose and cellular tissue, along the lower curved incision, and the extirpation is completed by detaching here also the skin from the subjacent parts, seizing the mamma, and severing its connection with the subcutaneous fatty tissue with scissors or a knife, having an assistant retract the lower skin-flap. After removal of the mamma, one carefully passes the finger over the edges of the wound, the surface of the pectoral muscle, and the subcutaneous fatty tissue, to ascertain whether there may not still be carcinomatous areas present. The tumour is frequently extensively adherent to the skin, or scattered carcinoma nodules are found in the latter. In such cases the involved skin should of course be removed at the same time, and an attempt at a linear union of the wound must, under certain circumstances, be given up. When this is the case, one may help himself out of the difficulty, however, by dissecting up and sliding over the edges of the skin, by means of pedunculated flaps from the immediate neighbourhood, by making liberating incisions at some distance from the borders of the wound, etc. Very large defects, even, may be closed by two tongue-shaped flaps from the upper and lower margin of the wound. These are formed by making a small perpendicular incision in the middle of each of the two

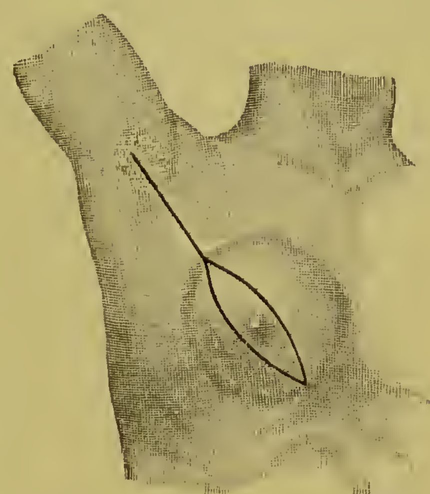


FIG. 362.—Amputation of the breast.

borders of the wound, and prolonging this in a curved line anteriorly and posteriorly.

After removal of the breast, and while the operator is cleaning out the axilla, Weis recommends the examination of frozen sections of the tumour for the purpose of ascertaining the completeness of the operation. Chiene places the tumour in a five-per-cent nitric-acid solution for ten minutes, after which it is rinsed off, and the carcinomatous areas are found to remain opaque and stand out distinctly in the semi-transparent tissue.

After the breast has been removed, the wound is covered with aseptic mull moistened in 1-to-1,000 bichloride, and the incision is made for opening and cleaning out the axilla, as indicated in Fig. 362. The incision runs in the middle of the axilla, parallel to the borders of the pectoralis major and latissimus dorsi muscles, or along the border of the latissimus dorsi, in order to secure an upper protecting flap for the vessels and nerves. All the adipose tissue of the axilla and any enlarged lymph glands that may be present are removed, partly by the fingers and partly by scissors or the knife. The large vessels and nerves of the axilla are often exposed for some distance in doing this. The best way is to detach the glands bluntly with the finger nail from the vessel sheath, especially that of the axillary vein, and thus avoid pulling too strongly on the mass of glands or the vein. If the wall of the vein is itself involved, a portion must be resected after tying it proximally and distally. Above all, the posterior surface of the pectoral muscle must be carefully examined. Numerous enlarged lymph glands are frequently found here in carcinoma, up as far as the infraclavicular and supraclavicular fossæ, and extending back beneath the scapula. These also should be thoroughly extirpated. One may, if necessary, divide the pectoral muscle as far as the clavicle, in order to facilitate the removal of the lymph glands. The two edges of the muscle are then united again with catgut. For the sake of preserving the normal mobility of the arm, special attention should be paid, in cleaning out the axilla, to the preservation of the subscapular nerves (F. Küster).

Finally, the hæmorrhage is carefully arrested, partly by ligation and partly by torsion of the vessels, and the entire wound surface is then lightly irrigated with a 1-to-1,000 bichloride solution. A stout drainage-tube is placed in the axilla through an opening in the lower skin-flap, near the border of the latissimus dorsi muscle. This reaches, if necessary, as far as the clavicular fossa. A second, smaller one is passed in through a hole in the middle of the lower skin-flap, and a third is placed in the anterior or lower angle of the wound. I consider

the insertion of drainage-tubes, especially glass ones, serviceable, in order to provide an escape for the subsequent bloody and serous discharge. If they are dispensed with, the blood not infrequently collects within the wound and prevents prompt healing. The wound is closed with two or three silver-plate sutures if necessary (see Principles of Surgery, page 108), and by a few deep silk tension sutures. The exact coaptation of the borders of the wound is secured by interrupted sutures of fine silk, and continuous catgut sutures (see Principles of Surgery, page 107, Fig. 89). By means of a continuous catgut suture, excellent coaptation of the borders of the wound is obtained, and hence a rapid healing by primary union. I do not usually employ silver-plate sutures at present, but only silk tension sutures, interrupted silk sutures, and a continuous catgut suture.

If the skin is extensively involved, an effort is made, as suggested above, to cover the defect, as far as possible, by dissecting up the edges of the skin and sliding them over the wound, making incisions to lessen the tension, if necessary, or cutting pedunculated flaps. If a defect remains, it may be closed by skin-grafting, either immediately, after arresting the hæmorrhage, or later, after scraping the granulating surface (see Principles of Surgery, page 141).

Application of the Dressing after Amputation of the Breast and cleaning out the Axilla.—The aseptic protective dressing is applied while the patient is in a half-sitting posture—that is, in the same position which she is to assume later in bed. In this way alone is a well-fitting dressing secured. Several layers of sterilized gauze are laid on the wound, and over that a large cushion of dressings, consisting of wood-wool, or mull stuffed with cotton or jute, which surrounds the entire thorax, and is so cut that it can be laid about the shoulders. The simplest dressing consists only of sterilized mull and absorbent cotton. The shoulder, the arm, and the axilla must be carefully protected from pressure by means of cotton. The dressing is fastened to the chest and the involved axilla by means of a broad mull bandage. The turns pass circularly around the thorax and the waist, around the neck and both shoulders, and, above all, the affected axilla must be carefully inclosed. The arm of the side operated upon, which is thoroughly wrapped in cotton, is laid

Fig. 363.—Dressing for amputation of the breast and cleaning out the left axilla.

on the thorax and secured in place with bandages. A large pad of cotton is laid in the axilla that has been operated upon, in order that the wound may be moderately compressed. The dressing has finally the form represented in Fig. 363.

The patient should assume a half-sitting position in bed, as the escape of the secretion of the wound is best secured in this posture. In case of an aseptic operation, the wound runs a favourable course. There is no fever, and the large wound heals quickly by primary union. The first dressing is changed at the end of three days. The drainage-tubes are removed, and the wound is frequently so far healed, after three or four days more, that the patient gets up. In other cases—e. g., those of very fleshy persons—the time of healing is protracted to from ten to fourteen days. I frequently remove the drainage-tubes, especially when the breast is small, twenty-four hours after the operation. If the wound could not at the time of operation be entirely closed by suture, complete healing requires a correspondingly longer time.

FOURTH SECTION.

SURGERY OF THE SPINE AND SPINAL CORD.

CHAPTER XV.

INJURIES AND DISEASES OF THE SPINE AND SPINAL CORD.

Anatomical and physiological remarks upon the spine and spinal cord.—Malformations (spina bifida).—Injuries of the spine and spinal cord.—Fractures and dislocations, with injuries of the spinal cord and spinal nerves.—Gunshot wounds of the spine and spinal cord.—Isolated injuries of the spinal cord without injury of the spine (concussion, compression, contusion, and wounds.—Curvatures of the spine.—Scoliosis.—Kyphosis.—Tuberculosis of the spine (tubercular spondylitis, suppuration of the vertebræ).—Gummatous (syphilitic) spondylitis.—Lordosis of the spine.—Spondylolisthesis.—Spondylitis deformans.—Tumours of the spine, the spinal cord, and its membranes.—Laminectomy.

§ 138. **Anatomy and Physiology of the Spine and Spinal Cord.**—The spinal column is originally straight in the fœtus and in infants. There gradually arises later, in consequence of the weight of the body and the traction of the muscles, a double (S-shaped) curvature—that is, the cervical and lumbar segments are arched forward and the dorsal and sacral portions backward. This lordosis of the cervical and lumbar segments and the kyphosis of the dorsal and sacral portions are entirely physiological. The spinal process of the seventh cervical vertebra projects prominently as a boundary between the cervical and dorsal segments of the spine. The seventh dorsal vertebra lies about on a level with the lower angle of the scapula. The twelfth dorsal vertebra may be recognised by the insertion of the last rib. The twelfth rib is sometimes very short and can scarcely be felt, so that one may mistake the eleventh rib for the twelfth.

With a finger in the mouth one can reach the fifth cervical vertebra, sometimes also the sixth, and in exceptional cases the seventh, or even the first dorsal. The epiglottis usually lies on a level with the fourth cervical vertebra, and the arytenoid cartilages are, according to some authorities, generally on a level with the fifth cervical vertebra; according to others, they are on a level with the upper half of the fourth. The cricoid cartilage is exactly opposite the sixth cervical vertebra and the lower portion of the body of the fifth (Waldeyer and Scheier).

The spine forms a support for the head, the trunk, and the upper extremities, and, by intervention of the pelvis, of the lower extremities also. It, moreover, forms a canal for the reception and protection of the spinal cord. In consequence of these functions of the vertebral column, it must possess a certain firmness as a whole, and must still be pliant and elastic, so as not to interfere with the movements of the body.

The firmness of the spine is secured by the solid structure of the single vertebræ, by a sort of paneling construction of its bone substance (K. Bardeleben), and by very stout connecting ligaments. In correspondence with the increasing weight supported by the lower vertebræ, they gradually increase in strength from the lower cervical and the upper dorsal sections downward.

The elasticity of the spine is conditioned upon the movable connection of the single vertebræ by means of articulations, upon the above-mentioned physiological curves of the vertebral column, and upon the insertion of elastic intervertebral disks, which may be compared to a yielding elastic cushion or pad. This elasticity of the spine lessens materially the shock of traumatisms to which it is exposed.

The movements possible to the spine are manifold. The column may be compared to a rod made up of individual movable parts, which is pliable in all directions and can be turned on its long axis. In other words, the spine is movable as a whole, and movements also take place between the separate vertebræ, especially rotatory movements. The degree of the mobility depends upon the thickness of the intervertebral disks, and upon the form and the direction of the articular processes. The pliability and mobility of the spine are greatest in the cervical and lumbar portions. The intervertebral disks are here thickest, and the form and direction of the articular processes most favourable for movement upon one another—that is, the axis runs in a direction as nearly sagittal as possible. The movements of the spinal column are the following: (1) Flexion and extension on a frontal or transverse axis, (2) lateral movements (abduction) on the sagittal axis, and (3) rotation on the longitudinal axis. In flexion a compression of the intervertebral disks and the bodies of the vertebræ takes place, and at the same time a stretching of the ligamenta subflava interposed between the laminæ of the vertebræ. At the same time the upper vertebra moves a little forward upon the one lying beneath it. In extension the process is reversed. Abduction is possible mainly in the lumbar and cervical sections of the column, and rotation in the cervical and dorsal portions. Abduction—e. g., of the cervical vertebræ—is usually combined with rotation. If, for instance, the head is approximated as nearly as possible to the shoulder, the chin is finally turned a little toward the opposite side.

Within the spinal canal, which is inclosed in front by the bodies of the vertebræ, and on the side and behind by the vertebral arches and the spinous processes, together with strong muscles and fasciæ, the spinal cord is found so suspended by a ligamentous apparatus that it does not touch the bony walls, and the movements of the spine are possible without crushing it. The spinal cord has the most room in the cervical portion of the vertebral column, where the canal has its largest circumference and the spine its greatest mobility. The dura mater of the spinal cord, a continuation of the

dura mater of the brain, is attached at the rim of the foramen magnum, and then is directly connected with the wall of the canal only at the intervertebral foramina by means of the dural sheaths that invest the spinal nerves. The dura mater is also connected at certain points with the posterior longitudinal ligament. There is a free space between the dura mater and the vertebral canal which is filled with loose cellular tissue and the venous sinuses. The spinal cord itself lies in the comparatively wide arachnoid space filled with cerebro-spinal fluid. It is held suspended in the same by its nerves running to the intervertebral foramina, and by the septa of connective tissue between the dura mater and the pia mater (ligamentum denticulatum). Regarding the significance of the cerebro-spinal fluid, see § 12, pages 86, 87.

The length of the spinal cord in adults is, according to Henle, from thirty-five to forty centimetres. Its upper boundary—i. e., the place of exit of the first cervical nerve—usually lies upon a level with the upper border of the posterior arch of the atlas. The apex of the conus medullaris lies, as a rule, in the region of the second lumbar vertebra. The nerve roots run from the second lumbar vertebra on almost parallel to the filum terminale of the spinal cord, in order to reach their place of exit from the vertebral canal, and form with the filum terminale the cauda equina.

The anatomy and physiology of the spinal cord have already been considered in § 12. The following brief statements may be added here: The white substance of the spinal cord consists, as is known, of medullary nerve fibres. The inner gray matter is composed of nerve cells and interlacing nerve fibres and also of numerous blood-vessels, etc. The anterior roots of the spinal cord (see *34*, *35*, Fig. 364) pass through the white substance without uniting with it, and then connect with the nerve cells of the anterior horns of the gray matter. The principal avenue of connection with the motor centres of the cerebrum is by means of the so-called pyramidal tracts (Türck. Flechsig), which lie partly in the lateral columns (crossed pyramidal fasciculus, see Fig. 364, *P S*), partly in the anterior columns (direct pyramidal fasciculus, Fig. 364, *P V*), come together in the medulla with decussation of the lateral fasciculi forming the pyramids, and, passing through the anterior division of the pons, the tegmentum of the crura cerebri, the internal capsule, etc., reach the cerebral cortex, chiefly the upper two thirds of the ascending frontal convolution, and the lobulus paracentralis. The exact mode of connection of the anterior roots with the fibres of the pyramidal tracts is not yet known. At all events, the lateral pyramidal fasciculi unite with the anterior roots of the same side; the anterior pyramidal fasciculi, perhaps, with the roots on the opposite side. The connection is probably as represented in Fig. 364, *30*, *31*.

The posterior roots enter in part the posterior columns ("root-zones," Fig. 364, *h W Z*, *m W Z*, *v W Z*), in part the "marginal zone" (Fig. 364, *R*) of the posterior horns. All the fibres are probably divided immediately after their entrance into an ascending and descending branch which then give off nerve fibres at right angles, the so-called collaterals of the posterior root fibres (Fig. 364, *1–5*). The ascending and descending branches, as well as the collaterals, pass over in part into the gray matter of the posterior horns, while the remainder continue upward in the posterior columns to the brain as the fasciculi cuneati and fasciculi graciles. The collaterals leaving the middle root-zone

(Fig. 364, *5*—probably sensory tendon nerves) end in Clarke's columns (Fig. 364, *33*), out of whose large cells fibres enter the peripheral zone of the lateral

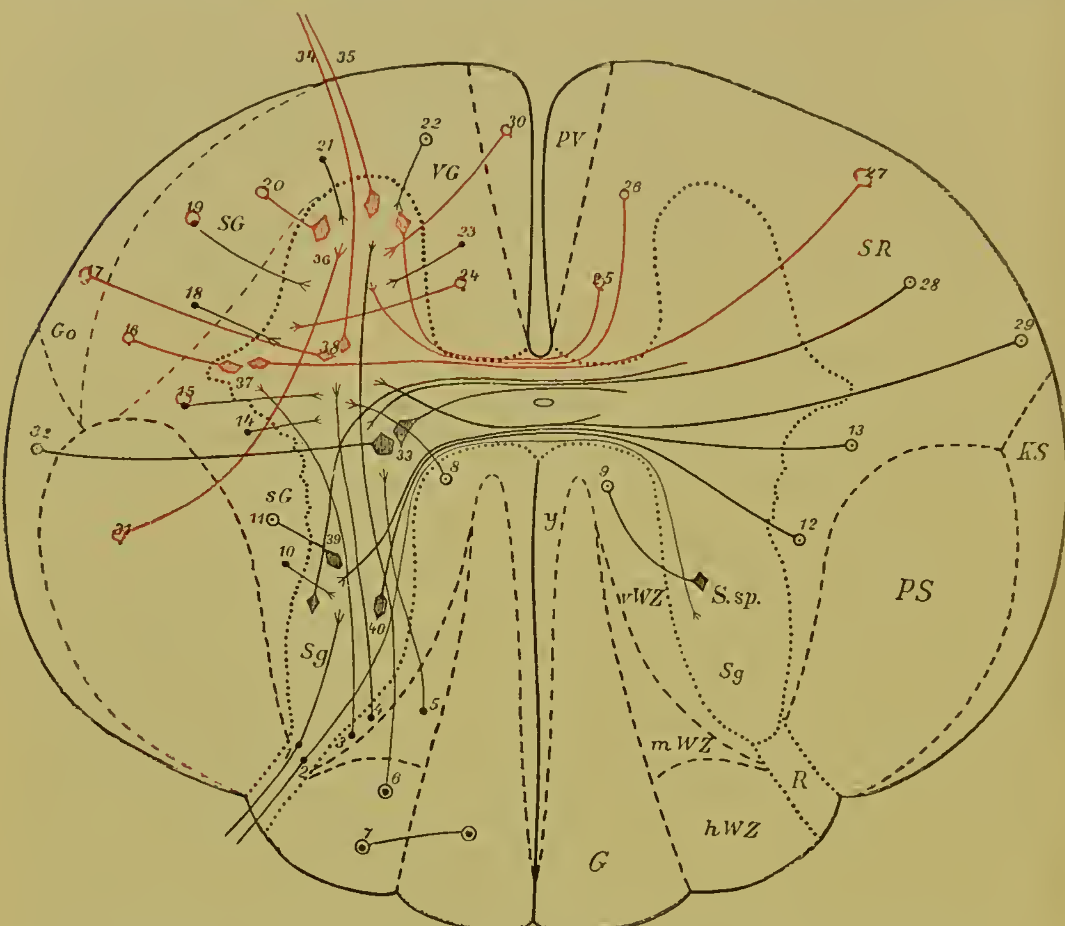


FIG. 364.—Cross section of the upper part of the dorsal segment of the cord (Flechsig).

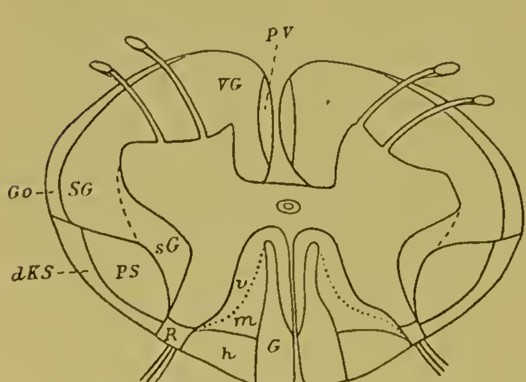


FIG. 365.—Cross section of the cervical enlargement of the cord (Flechsig).

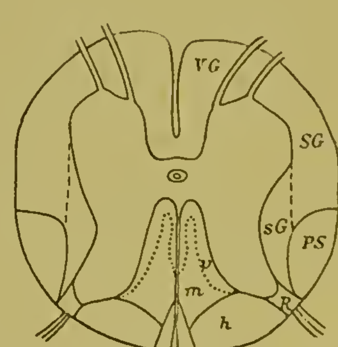


FIG. 366.—Cross section of the lumbar enlargement of the cord (Flechsig).

v anterior, *m* middle, *h* posterior — Root zones of the posterior columns.
G Goll's columns.
PV Anterior pyramidal tract.
PS Lateral pyramidal tract.
G o Gower's bundle.
d KS Direct cerebellum—lateral column tract.
S G Fundamental lateral fasciculi.
V G Fundamental anterior fasciculi.
s G Lateral boundary layer of the gray matter.
R Marginal zone of the posterior horns.

columns to ascend to the cerebellum (direct cerebellar column, Fig. 364, *32*). The collaterals of the "anterior" root-zone (Fig. 364, *3*, *4*, *8*) pass into the centre of the anterior horns. Single collaterals of the "posterior" root-zone (Fig. 364, *6*) pass forward between the large cells at the apex of the anterior horns. Other fibres of the posterior root-zone, as well as of Goll's columns (Fig. 364, *G*), ascend to the nuclei of the posterior columns. The collaterals of the marginal zone of the posterior horns (Fig. 364, *1* and *2*) pass through the substantia gelatinosa (Fig. 364, *S G*) into the substantia spongiosa (*S, sp.*, Fig. 364) of the posterior horns, in part end here, and in part continue through the posterior commissure into the substantia spongiosa of the opposite side.

Fibres from the cells of the posterior and anterior horns (Fig. 364, *11*, *16*, *17*, *20*) connect with the portions of the lateral columns that remain (lateral-column residue, Flechsig) after deduction of the crossed pyramidal fasciculi and the cerebellar column. On the other hand, numerous fibres of the lateral-column residue (Fig. 364, *S R*) join the gray matter (Fig. 364, *10*, *14*, *15*, *18*, *19*, *21*) either directly or by means of collaterals. The same is true of the fundamental anterior fasciculi of the anterior column (Fig. 364, *V G* and *22–26*). There are, furthermore, three divisions of the residue of the lateral columns: (1) A peripheral (Fig. 364, *Go*, Gowers's bundle); (2) one adjacent to the gray matter (Fig. 364, *s G*), the "lateral boundary layer of the gray matter"; and (3) a zone lying between them, uniting in front with the fundamental fasciculus of the anterior column, called the fundamental fasciculus of the lateral columns (Fig. 364, *S G*). The nerve fibres of the lateral-column residue and fundamental fasciculus of the anterior column in part unite the different levels of the spinal cord with one another (longer and shorter reflex tracts), and in part unite the gray matter of the spinal cord with the medulla oblongata, especially Gowers's bundles and the "lateral boundary layer of the gray matter."

The different size and position of the systems that have just been named at the different levels of the spinal cord are schematically represented in Fig. 365 (middle of the cervical enlargement) and Fig. 366 (middle of the lumbar enlargement). It is shown that the direct pyramidal fasciculi and the lateral cerebellar fasciculi are first present above the lumbar enlargement.

The spinal cord possesses neither volition nor sensation. It is essentially a conduction organ or connecting organ for the nerve conduction between the brain and the rest of the body in a centrifugal and centripetal direction. The spinal cord can, moreover, by means of intermediate connections located within itself, especially of the ganglia of the gray matter, change sensory (centripetal) into centrifugal motor impulses (reflex movements). We have already given on page 98 the paths for the ascending (sensory) and the descending (motor) conduction and for the reflex tracts. The time consumed in the reflex transmission of a sensory impulse to a motor fibre has been measured by Helmholtz, and found to be from one thirtieth to one tenth of a second.

There are various centres in the spinal cord for classified reflex movements. I mention especially the following: The centre for the patellar reflex probably lies between the third and fourth lumbar vertebræ. When the posterior column is diseased this reflex is absent. The patellar reflex

consists, as is known, in the occurrence of contractions of the quadriceps upon striking the ligamentum patellæ or the tendon of the quadriceps below the patella (Erb, Westphal). Clonic contractions of the muscles of the calf of the leg occur in the same way upon striking the tendo Achillis (ankle clonus). These tendon reflexes are only brought about by mechanical stimulation.

The centre for defecation (centrum ano-spinale) lies in dogs at the level of the fifth lumbar vertebra, the centre for micturition (centrum vesico-spinale) below that for defecation. There is also a centre for the emission of semen and for parturition. Of the automatic centres for co-ordinated movements—that is, centres that are not at all or very slightly influenced by volition—we mention especially the vasomotor centres (Schiff, Goltz): The centre for the posterior extremities in the upper part of the lumbar segment and the lower part of the dorsal segment of the cord is the best known (Ostroumoff). Here lies also, according to Luchsinger, the sweat centre for the posterior extremities. The cilio-spinal centre for the tonic stimulation of the dilatator pupillæ lies, according to Budge, in the region of the lowest cervical and the uppermost dorsal vertebra. Finally, the centre for the tonus of striated muscles is still to be mentioned. It is assumed that the striated muscles are always maintained in a certain state of contraction or tension from within the spinal cord. This muscle tonus is probably not automatic, but rather of a reflex nature, as in the tendon reflexes, because, after section of the posterior (sensory) roots of the spinal cord, a slight lengthening of the leg immediately follows (Brondgeest).

In the white posterior columns and parts of the lateral columns are transmitted the tactile sense, the temperature sense, and the muscular sense. After injury or degeneration of the posterior columns, as well as of the gray posterior horns in which these fibres originate—e. g., in tabes dorsalis—sensory disturbances in the skin are therefore observed besides disturbances in co-ordination (ataxia). There is no longitudinal conduction of great extent in the gray matter of the spinal cord, so that the statement of Schiff that the gray matter conducts the sensation of pain seems scarcely credible, as does the assertion that after complete section of the gray matter there is absolute anæsthesia below the place of section. If the posterior columns are uninjured analgesia is observed, as in mixed morphine-chloroform narcosis or in awakening from narcosis—that is, the patient has no sensations of pain resulting from the operation. He is conscious, however, controls his movements of swallowing, etc. The motor impulses are conducted from the brain to the motor nerves, according to C. Ludwig and Woroschiloff, in the white anterior and lateral columns. The respiratory and the vasomotor nerves run in the lateral columns without entering the ganglia of the spinal cord, also the tracts for the reflex excitation of the vasomotor nerve centre, which undergo, according to C. Ludwig and Miescher, an incomplete decussation. With reference to the anatomy and physiology of the medulla oblongata, see § 12, page 95.

From a pathological standpoint the ascending and descending secondary degenerations are of special interest—e. g., those following the injury of a definite part of the brain and the spinal cord. These degenerations arise in consequence of separation of the involved nerve fibres from their trophic

centres. Descending degeneration ensues in consequence of the interruption of conduction in motor tracts, ascending degeneration in connection with the lesion of sensory tracts of the spinal cord. When the brain is diseased, descending degeneration of the motor tracts of the spinal cord is observed, also of the direct pyramidal tracts of the anterior columns, as well as of the crossed pyramidal tracts of the lateral columns. The first lies upon the same side as the injury to the brain, the latter upon the opposite side. In lesions which involve more or less the whole transverse section of the spinal cord there occurs a secondary descending degeneration of the pyramidal tracts below the injured place, while the secondary ascending degeneration above the lesion affects mainly Goll's columns and the lateral cerebellar tracts. The symptoms of the ascending secondary degenerations are not known as such. Spasms and contractures of the muscles as well as increase in the tendon reflexes are indications of descending degenerations. Unilateral lesions of the spinal cord produce motor disturbances upon the same side and sensory disturbances upon the opposite (uninjured) side, because the sensory tracts cross after their entrance into the spinal cord, with the exception of the fibres for the muscular sense, which ascend without crossing to the brain. The muscular sense disappears, therefore, on the injured side (Brown-Séquard).

Diseases of the spinal cord appear either as so-called "system lesions"—that is, they attack chiefly those fibres which belong together embryologically and physiologically—or they spread over more or less of the transverse section. In order to determine the location of a transverse lesion in the longitudinal axis of the spinal cord, one takes into consideration, above all, the existing functional disturbances—that is, any injury that may have occurred, symptoms of irritation and paralysis, changes in the reflexes, functional disturbances in the above-mentioned automatic centres, the centres for the pupils, those for micturition and defecation, for the emission of semen, for parturition, etc.

§ 139. **Deformities of the Spine and Spinal Cord (Hydrorrhachis, Spina Bifida).**—By hydrorrhachis, or spina bifida, is understood a malformation of the spine and the spinal cord in the form of a cleft or defect with protrusion from the vertebral canal of a tumour, consisting of the spinal membranes or of the spinal cord as well (see Figs. 367, 368).

It is analogous to hernia cerebri (cephalocele). There is usually a congenital cleft in the vertebral arches or the spinous processes, and hence the designation "spina bifida." Clefts of the bodies of the vertebræ also occur, especially in a sagittal direction. There is not always a cleft or defect in the vertebral arches in connection with hydrorrhachis, but the hernial protrusion takes place between the single vertebral arches. Rhachichysis—that is, a cleft of the spine, with defective formation of the spinal cord, with partial or local congenital amyelia, or even division of the spinal cord into two halves (diastematomyelia)—is to be distinguished from spina bifida with the hernialike tumours proceeding from the vertebral canal.

Spina bifida is found most frequently in the lumbar and sacral regions (spina bifida lumbalis, lumbo-sacralis, spina bifida sacralis), much less often in the cervical or dorsal regions (spina bifida cervicalis and dorsalis).

We distinguish anatomically three varieties: 1. Spinal meningocele—that is, a hernial protrusion of the pia mater filled with cerebro-spinal fluid without participation of the spinal cord. 2. Myelomeningocele is the commonest form. The spinal cord here participates in the formation of the sac. The latter is made up of the pia, while the

Fig. 367.—Spina bifida cervicalis (meningocele) in a female infant ten weeks old which was cured by operation.

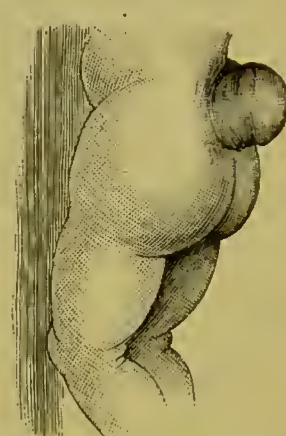


Fig. 368.—Spina bifida lumbalis (myelomeningocele) in a male infant three months old.

spinal cord is lost at the entrance of the sac, apparently dividing into smaller cords. The latter run in the wall of the sac and unite again upon returning to the spinal canal. In the sacral myelocele the conus terminalis of the spinal cord is sometimes adherent to the skin. 3. The myelocystocele is a tumour resulting from the dilatation of the central canal of the spinal cord.

The fluid contained in all these cystic tumours is usually clear and of the same chemical composition as the cerebro-spinal fluid—i. e., it contains small amounts of sugar and albumin. The size of a spina bifida varies from that of a hazelnut to that of a fist or over. The tumour is sometimes more or less translucent when it is of large size and under considerable tension. The communication between the cavity of the cyst and the vertebral canal may be either wide or narrow, and it is sometimes absent altogether. If there is a wide communication, the skin over the greater fontanelle on the skull rises when pressure is made upon the tumour.

Spina bifida is really to be regarded as a congenital malformation due to arrested development and is usually the result of a defect in the ver-

tebral arches. Opinions differ as to whether the defect in the vertebral arches is primary or is conditioned secondarily upon inflammatory effusions or increase of fluid from any cause in the vertebral canal. Both methods of origin would seem possible. Congenital rhachitis of the vertebral column is also held responsible. At any rate, the etiology of hydrorrhachis is not perfectly simple, and our knowledge regarding its method of development, which is certainly varied, is still very defective. According to Recklinghausen, Muscatello, Hildebrand, and others, the different forms of spina bifida correspond to different degrees of disturbances in development. Rhachichysis and the myelomeningoceles, which represent the most advanced forms of spina bifida, result from non-closure of the spinal column and from defective development of the spinal membranes and the soft parts of the region of the back, including the epithelial covering. The tumour in the case of a myelomeningocele results from a collection of fluid in one or more subarachnoid spaces in consequence of chronic inflammation of the soft membranes of the spinal cord. The myelocystocele is due, according to Recklinghausen, to interference with the longitudinal growth of the spinal column, so that the canal for the normally growing spinal cord becomes comparatively too short, and hence circulatory disturbances and inflammatory processes with dilatation of the vertebral canal result. Hydrorrhachis is not rare, occurring about once, according to Wernitz, in every one thousand births. It is rather frequently combined with other malformations—e. g., with ectopia vesicæ, and especially with hernia cerebri (cephaloceles, see § 22, page 156).

The symptoms of spina bifida are very varied. A large percentage of the children thus affected die soon after birth. According to Wernitz, of ninety children who were not operated upon, the majority died within the first five weeks, and only twenty lived to be over five years old. Nervous disturbances may be altogether absent, especially in external hydrorrhachis. There is usually paralysis, however, in consequence of pressure of the fluid or of malformation of the spinal cord. This varies, of course, according to the location of the tumour. In accordance with the most frequent location of spina bifida near the lower end of the spinal column in the lumbar and sacral regions, paralysis of the lower extremities, the bladder, and the rectum are usually observed. If there is strong pressure—e. g., owing to compression from without, or in consequence of increase of fluid resulting from inflammatory processes—more fluid is forced up into the cranial cavity or the ventricles of the brain, and then convulsions may ensue. Spontaneous disappearance of the tumour is rare but possible, especially when the sac, not communicating with the vertebral canal, bursts, or, in consequence of inflammatory processes, contracts and becomes obliterated. It is also a favourable circumstance if the tumour remains stationary. It usually, however, gradually increases in size, and in case of rupture, if the sac has a wide communication with the central canal of the spinal cord or with the brain, death may very speedily ensue in consequence of the emptying of the central canal and the ventricles of the brain or from acute inflammation of the spinal membranes and the cord—e. g., in case the fluid escapes slowly. The opening sometimes closes from time to time, so that several ruptures may take place. If there is no communication with the spinal cord, or if it is very

small, open fistulæ are frequently well borne. The tumour sometimes bursts *in utero*, so that children are then born with an open fistula or with the place of the rupture already cicatrized. Spina bifida is sometimes complicated with tumour formation, in which case we have usually to do with lipomata, fibro-lipomata, or cavernomata.

The diagnosis is, as a rule, easy, since the condition is thoroughly characteristic. One usually sees in the median line of the back, most frequently over the lumbar segment of the spine, a circular, sessile, or more pedunculated, fluctuating tumour which can be reduced in size by pressure, especially if it has a wide communication with the vertebral canal or spinal cord. This pressure must be exerted with caution, as otherwise convulsions may easily ensue. A marked bulging over the greater fontanelle may result from pressure upon a tumour that has a wide communication with the vertebral canal. When the child cries, one can usually notice that the tumour becomes more tense. At the base of the latter one can generally feel the gap in the vertebral arches. Spina bifida may be confounded with lipoma in the subdural adipose tissue of the vertebral canal (Virchow, Drachmann), and especially with congenital sacral tumours proper. (For a description of the latter, see Surgery of the Pelvis.) The differential diagnosis of the separate varieties of spina bifida—which is very important as regards treatment—is sometimes easy, but may be very difficult. It is particularly difficult to distinguish between meningocele and myelocystocele. The diagnosis of myelomeningocele is usually made from the character of the outer wall (the medullo-vascular area, the epithelio-serous and cutaneous layers), the frequency of functional disturbances of the legs, the rectum, and the bladder, the size of the opening in the bone, etc. Occasionally tumours, such as a lipoma or a fibro-myolipoma, that are situated over a cleft in a vertebra and are connected through the cleft with the spinal cord, which they surround (spina bifida occulta, Recklinghausen, Ribbert), may be mistaken for spina bifida.

The treatment of spina bifida consists in evacuation and obliteration of the sac—that is, one seeks to accomplish that which in rare cases occurs spontaneously. Opinions differ as to the operative treatment of this condition. Generally speaking, meningoceles alone are capable of successful surgical treatment. The myelocystocele is never adapted to operative treatment, and the myelomeningocele usually only in exceptional cases (see also pages 759 and 762). Muscatello advises against operation for myelomeningoceles, while in the simple uncomplicated myelocystoceles the removal of the sac may be called for. Hydrocephalus, according to the same authority, is a contraindication to the operative treatment of all forms of spina bifida. Operative treatment may be tried, moreover, in all rapidly growing tumours where perforation is threatened, and in cases where paralysis of the lower extremities, the bladder, the rectum, etc., exists. But in the latter cases one will probably desist from operation, as the paralysis can usually not be improved. Small reducible tumours may be held back by a truss, and their enlargement prevented in this way.

The operative treatment of spina bifida may take one of four forms: (1) Puncture of the sac with or without the injection of tincture of iodine, absolute alcohol, etc.; (2) ligation; (3) incision; and (4) excision.

Puncture is performed with a hypodermatic syringe having a rather large needle, or with a fine exploring trocar, under strict antiseptic precautions. The puncture is made in an oblique direction where the wall is not too thin, and the fluid contents of the sac is allowed to escape slowly or, better, is aspirated. In this way the sac may be wholly evacuated at one sitting (Brainard). At all events, enough fluid should be removed from the sac to cause perceptible relaxation of its walls. After evacuation of the sac one half to one gramme of tincture of iodine is injected, either pure or mixed in equal parts with absolute alcohol, or pure absolute alcohol, or Brainard's solution of iodine, which consists of pure iodine, 0·25; iodide of potassium, 0·75; and distilled water, 30·0. During the injection the opening between the vertebræ should be kept closed with the fingers of the left hand. In case of a pedunculated spinal meningocele (external hydrorrhachis), one can shut off the hernial orifice beforehand by means of a ligature or subcutaneous purse-string suture. After the injection, Brainard, who has had good results from his treatment of spina bifida, allows the injected fluid to escape and then fills the sac with distilled water. After removal of the needle an aseptic dressing, which exerts pressure, is applied, consisting of iodoform gauze or sublimate gauze and a moss cushion or cotton. A moderate inflammatory reaction then usually ensues. One is obliged, generally at intervals of from six to ten days, according to the degree of the reaction, to repeat the puncture several times—e. g., from three to five times—before a permanent cure is effected. Before a new puncture and injection, one must always wait until the effect of the preceding injection has wholly disappeared. Brainard and Crawford in particular have secured very favourable results from puncture and the injection of tincture of iodine. According to Journée and Debout, fourteen out of eighteen cases were cured in this way, among them cases in which there was paralysis of the bladder and the extremities.

Ligation of the sac has likewise been sometimes successful (F. Parona). The application of an external ligature is, generally speaking, dangerous, as inflammation and suppuration of the sac ensue so easily, and it is therefore less used at present. The material employed was an India-rubber band, silk thread or silver wire, or one utilized special clamps—e. g., similar to Dupuytren's enterotome (see Surgery of the Intestines), or the clamp used in the extraperitoneal treatment of ovarian pedicles (see Ovariotomy). Subcutaneous ligation is per-

formed with catgut. As already said, I consider ligation inadvisable. At all events, it is admissible only in rare cases of pedunculated meningoceles.

Aseptic incision, with excision of as much of the sac as possible, is a method which, since the adoption of antiseptic surgery, has been used more frequently and sometimes with success (K. Bayer, the author, and others). Hildebrand has collected from the literature of the last ten years eighty-seven operated cases with sixty-four (73·5 per cent) cures. As De Ruyter and others have recently shown, however, the final results attending the operation are not favourable, and the indications for the same should be decidedly restricted. The nature of the spina bifida should be exactly determined in each case before the operation. Meningoceles are especially adapted to operation, as has been mentioned, and even though they of themselves involve no danger to life, they should nevertheless always be operated upon, for the reason that otherwise in later years disturbances of sensibility, paralytic conditions, and neuroparalytic ulcers on the lower extremities are likely to develop. As regards operation on myelomeningoceles and myelocystoceles opinion is divided, but in the majority of cases I regard operation as hopeless. De Ruyter properly recommends that operation upon a spina bifida, just as upon an encephalocele on the skull, should begin by exposing the inferior pole of the tumour, in order to determine the condition of the spinal column here—that is, whether it is here closed or continues open into the groove of the coccyx. The latter is the case in all myelomeningoceles, and the former is usual in meningoceles. One must seek to prevent the escape of cerebro-spinal fluid by careful suture of the wound. In meningoceles, after dissecting up the skin, the sac should be removed as completely as possible, and any adherent nerves are to be spared and replaced. The margins of the wound in the membranes of the cord are then to be sutured together, and the skin, together with the muscles and fascia, likewise approximated. In myeloceles König and Hildebrand recommend a lateral incision for the purpose of ascertaining the course of the nerves. If the latter are free in the sac, one then cuts around the medullo-vascular area—i. e., the wall of the spinal cord and its nerves—replaces it in the groove of the spinal column, and, after extirpation of the superfluous portions of the sac, sutures the overlying soft parts and the skin-flap. If the nerves run in the wall of the sac, one should replace the entire meningeal sac which has been dissected free and suture the skin over it. The experience of Polaillon and Monod shows that the nerve trunks which spread out over the wall of a lumbar spina bifida are only of importance for the lower extremities when the latter

are paralyzed, but otherwise have nothing to do with their innervation, and may be destroyed in case they do not re-enter the spinal canal. Myelocystoceles may be treated like meningoceles, or the emptied sac may be replaced in the spinal groove and covered by soft parts that are then sutured to the skin, or by flaps of skin and muscle. Large vertebral defects should, according to König, always be closed by flaps of skin and muscle, or of skin, muscle, and nerves. Dollinger closes the defect by breaking in the remnants of the arches at their base, and uniting them by suture of the periosteum.

§ 140. **Fractures of the Spine** are comparatively rare. They constitute, according to Gurlt, 0·332 per cent of all fractures. Among 22,616 fractures in the London Hospital, there were but seventy-five of the spine. They are observed more frequently among men than among women because the former, in consequence of their occupations, are much more exposed to accidents.

The fractures are either complete or incomplete (fissures). They may also be linear or comminuted fractures, etc.

Fractures of the spinal processes are most frequent and occur especially on the lower cervical and upper dorsal vertebræ, where they are longest. Fractures of the spinous processes are usually combined with those of other parts of the vertebræ—e. g., the body or the arches.

Fractures of the articular processes alone occur most frequently in connection with dislocations.

Isolated fractures of the transverse processes are rare. They occur most frequently in the lumbar segment of the spine, where they are longest.

Transverse fracture of the odontoid process of the axis at its base, with or without fracture of the arch of the atlas or axis, is rather frequent. Isolated fracture of the atlas occurs only in dislocations.

Fractures of the vertebral arches are most frequent on the fourth, fifth, and sixth cervical vertebræ, because these are oftenest exposed to direct violence. The fracture is usually bilateral.

The most common fracture of the spine is that of the bodies of the vertebræ, which occurs especially in those of the lower dorsal and the lumbar region. Incomplete fractures of the spine include fissures and crushing of the spongy tissue of the vertebral bodies, which at the time can hardly be diagnosed as fractures, but later the resulting ostitis causes a typical kyphosis with perhaps compression of the cord. Among complete fractures of the vertebral bodies, those produced by compression are of special interest (see Figs. 369 and 370). In these fractures the involved vertebræ may be completely crushed into separate fragments, and the vertebra above may become more or less im-

pacted within the one that is crushed. In these fractures of the body of vertebræ from compression the spinal cord is frequently severely injured. Splinters also may be completely detached and driven

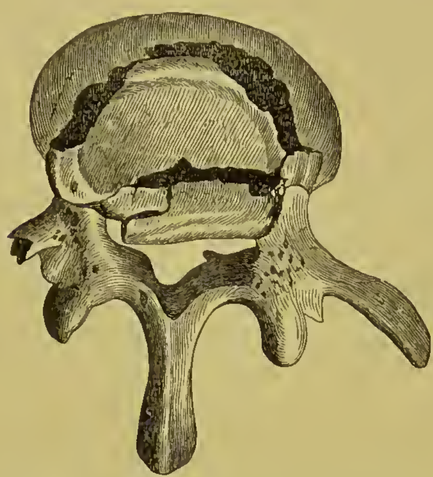


FIG. 369.—Fracture of a lumbar vertebra by compression (Middeldorpf and Gurlt).

FIG. 370.—United fracture of a lumbar vertebra. (Pathological collection at Leipsic).

into the vertebral canal (Fig. 371, inner view of Fig. 370). If a vertebra is divided by the fracture into two fragments, the line of fracture generally runs obliquely from above and behind downward and forward, or transversely, seldom longitudinally from above downward. In transverse, and especially in oblique fractures, the displace-

FIG. 371.—Separation of a portion of bone (×) and displacement of the same into the spinal canal; the same specimen as Fig. 370, seen from the inside.

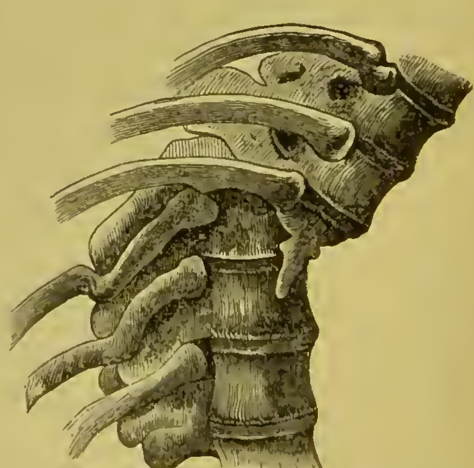


FIG. 372.—Transverse fracture of the ninth and tenth dorsal vertebræ with marked displacement (Gurlt).

ment of the vertebræ is sometimes considerable (see Fig. 372), so that the spinal cord is severely crushed (Fig. 373), or even completely divided. In the lumbar and lower dorsal region especially a particular kind of oblique fracture is observed, which runs in a direction opposite to that of most oblique fractures—that is, from behind and below upward and forward. This is the so-called "upper posterior wedge fracture" (Ponfic-Tschammer)—i. e., a more or less wedge-shaped piece of bone is detached from the posterior upper surface of a vertebra, owing to compression of the vertebra, or from being torn away by the intervertebral disks in consequence of forced flexion. As seen in Fig. 371, an analogous fracture with separation of fragments occurs on the lower posterior surface of the vertebræ in consequence of compression. In distortions also fractures of the lower surface of the vertebræ are observed in which a piece of bone is torn away by the intervertebral disk.

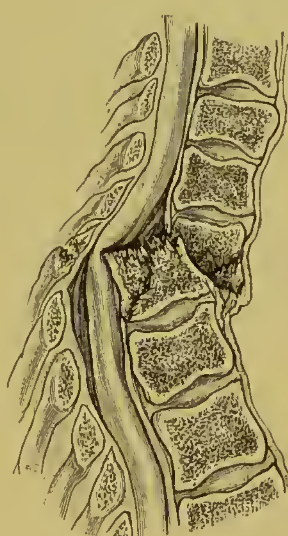


Fig. 373.—Fracture of the fourth and fifth dorsal vertebræ with marked compression of the spinal cord caused by a fall from a great height.

Fractures of the spine are not infrequently combined with subluxations and luxations. The secondary injuries to the soft parts, including the ligaments, the intervertebral disks, the muscles, the vessels, and, above all, to the spinal cord and its membranes, are sometimes considerable. In the milder cases there occurs a concussion merely of the spinal cord without demonstrable anatomical lesions, just as in concussion of the brain In other cases, however, the spinal cord is sometimes compressed by an effusion of blood or by the fragments, and sometimes directly injured. In the more severe cases it is crushed to a bloody pulp and completely severed.

Etiology of Fractures of the Spine.—Fractures of the spinal column occur most frequently as the result of indirect violence—e. g., from a fall from a height upon the head, the shoulders, the buttocks, or upon the feet, from being buried up, or from the fall of a heavy weight upon the head, the shoulders, and the thorax. Direct fractures of the spine are less common. They occur most frequently from being run over or from gunshot wounds, and, on the spinous processes, from a blow. In fractures from indirect violence the fracture arises sometimes from compression and sometimes from hyperflexion or hyperextension of the vertebral column. The resistance of the vertebræ under a perpendicular load is large, according to Messerer. At the third cervical vertebra it is one hundred and fifty kilogrammes, and it then gradually increases as far down as the fifth lumbar

vertebra, which supports a weight up to four hundred and twenty-five kilogrammes. According to Malgaigne, Philippeaux, and Hoffa, fractures of the vertebræ occur especially at those points where a relatively pliable portion of the spinal column is united with one that is less movable. Fractures are, accordingly, most frequent at the fifth and sixth cervical, the last dorsal, and the first lumbar vertebræ.

Fractures of the vertebral arches and the articular processes occur most commonly in consequence of forced flexion, extension, abduction, and rotation of the spinal column.

A normal vertebra does not break from muscular action alone, but may do so in case its power of resistance has been lessened in consequence of pathological conditions—e. g., by tumours, spondylitis, etc. Verneuil and Polaillon, however, have seen fractures or crushing of the vertebræ result from a severe muscular effort in otherwise perfectly healthy individuals. In such cases the spongy tissue of a vertebral body is crushed (see page 763), or the vertebral body is simply compressed. According to Weber, fractures of the spine from muscular action may occur in animals, especially horses, when their legs are bound together and they struggle to get free.

Among predisposing causes of vertebral fractures, aside from spondylitis, which has just been mentioned, and tumours (sarcoma, carcinoma), there are especially to be included senile osteoporosis, syphilis, erosion of the bone from aneurisms of the aorta, arthritis deformans, etc.

The symptoms of fracture of the spine are in part local in consequence of the injury to the bone and, it may be, the spinal cord, in part more general nervous manifestations resulting from the shock and especially from the concussion of the brain and spinal cord. By shock is understood, as is well known, a peculiar condition of depression of the nervous system resulting from reflex paralysis of the vasomotor centre in the medulla oblongata (see Principles of Surgery, § 63, p. 313). For a description of concussion of the brain and medulla the reader is referred to § 13. The symptoms of shock and concussion of the brain and medulla are present in varying degree. The true clinical picture of a fracture of the spine, with or without injury of the spinal cord, is not infrequently disturbed by the presence of injuries of the brain also, by fractures of the skull, and by intracranial hæmorrhage (compression of the brain); and for the symptomatology of these injuries of the head the reader is referred to §§ 8–17.

The symptoms proper of fracture of a vertebra are essentially the same as of other fractures. We consider here, in the first place, the more important fractures of the bodies of the vertebræ because the characteristic symptoms of a fracture are most pronounced in them. The pain is sometimes spontaneous and is sometimes caused by pressure and any attempt at active or passive motion. The deformity at the point of fracture is frequently very evident. There is often a

marked kyphosis at that point, or, on the contrary, there is flattening or a depression. As is seen from Figs. 372 and 373, the kyphosis may be very pronounced in the case of fractures from compression, or in transverse and oblique fractures of the bodies of the vertebræ, accompanied by displacement of the upper fragment, with the part of the vertebral column lying above it forward and downward over the lower fragment. The vertebra above may lie wholly in front of the one below. The spine is then depressed above the abnormal projection of the spinous processes, so that the spinous processes are here to be felt only indistinctly (see Figs. 372 and 373). Sometimes the depression and sometimes the abnormal projection of the spinous processes is more prominent. Depression at the site of the fracture is common also in fractures of the vertebral arches. A marked lateral curvature of the spine is sometimes found, especially in lateral fractures from compression.

In fractures of the cervical vertebræ, particularly the two upper ones, the head is deflected forward or to the side. Dysphagia not infrequently exists in connection with fractures of the cervical and dorsal vertebræ, in consequence of the pressure of displaced fragments and extravasations of blood upon the pharynx and the œsophagus.

The deformity either is apparent immediately after the injury or it develops or is increased supplementarily—e. g., in transporting the patient, or in consequence of careless movements during the examination.

Abnormal mobility and crepitus are not usually demonstrable in fractures of the bodies of vertebræ, because they are not accessible to direct palpation, and are too firmly fixed by the muscles and ligaments or by impaction of the fragments. In fractures of the vertebral arches and the spinous processes, however, crepitus and abnormal mobility are often easily made out, and also in fractures of the cervical vertebræ, by means of combined palpation from within the pharynx and from the outside.

The complicating secondary injuries in fractures of the spine are very numerous; they include fractures of the skull, injuries of the thoracic and abdominal organs, and, most important of all, injuries to the spinal cord. Rivet saw death result from incarceration of the intestines between the fractured and dislocated second and third lumbar vertebræ.

The symptoms of injury to the spinal cord are conditioned partly upon concussion, partly upon compression or actual injury of the cord at the site of the fracture.

In concussion of the spinal cord in consequence, for example, of a fall from a considerable height, there are constitutional disturbances

present, as in concussion of the brain alone. These are generally conditioned in part upon the concussion of the brain that occurs simultaneously. Here also in the cases of pure concussion of the spinal cord, as in concussion of the brain, there are no anatomical changes demonstrable either microscopically or macroscopically. One finds motor and sensory disturbances in varying degree, consisting in muscular weakness, sometimes amounting to pronounced paralysis, in paræsthesia, hyperæsthesia, or anæsthesia. These motor and sensory disturbances are either present immediately after the injury or they appear later. Complete recovery may ensue, but the disturbances often increase, and a condition of chronic invalidism or chronic myelitis is developed. Patients with such a traumatic neurosis resulting from concussion of the spinal cord are sometimes unjustly suspected by inexperienced physicians of practising simulation. In this category belong also those characteristic cases of "railway spine" (traumatic neurosis), which were first observed by Erichsen and other English physicians, as following concussion of the spinal cord, in connection with railway accidents (see also page 788 ff.).

In compression and injury proper of the spinal cord the disturbances depend in part upon the location of the fracture and in part upon the degree of the injury to the cord. The functional disturbances which here occur consist especially in manifestations of irritation (pain, hyperæsthesia, muscular spasms), in paralysis, in disturbances of reflex excitability and of the vasomotor nerves, as well as in changes in the temperature of the body. Compression acts both locally upon the spinal cord or the nerve fibres and in a more general way upon the circulation of the cerebro-spinal fluid in the cord. The interference with the circulation of the cerebro-spinal fluid caused by sudden narrowing of the vertebral canal leads to the transudation of fluid from the blood-vessels of the gray matter and to a dilatation of the central canal as compensation for the narrowing. The lymph that escapes in consequence of the congestion permeates the gray matter and brings about a necrosis or absorption of the tissue in places with the formation of clefts and cavities (P. Rosenbach, A. Schtscherback).

The above-mentioned symptoms of irritation are mostly of only short duration. The motor and sensory paralyses take the form, according to the injury of the spinal cord, sometimes of paraplegia and sometimes of hemiplegia. The higher the fracture and the injury of the spinal cord, the more extended, naturally, is the disturbance of innervation.

Considering first the complete transverse lesions of the spinal cord, we shall find in fractures of the atlas and axis, with such an injury of

the cervical portion of the spinal cord, complete sensory and motor paralysis of the entire body excepting the head. Immediate death here follows frequently from paralysis of the diaphragm, when both phrenic nerves are paralyzed. The phrenic nerve arises mainly from the fourth cervical nerve, but it contains fibres also from the third and fifth cervical nerves. Among thirty-two cases, according to Luschka, the phrenic nerve had its origin twelve times solely in the fourth cervical nerve. An immediately fatal paralysis of the phrenic nerves may therefore also result from fracture of the third and fourth cervical vertebræ. In all fractures of the cervical vertebræ with injury of the spinal cord disturbances of the pupils (dilatation or contraction, with immobility) are also observed. The fibres of the sympathetic supplying the pupil have, as is well known, their main centre in the spinal cord (cilio-spinal centre, Budge), which lies on a level with the lowest cervical and upper dorsal vertebræ. They pass through the anterior roots of the first two dorsal nerves into the communicating branches. Paralysis of the sympathetic nerve causes contraction, stimulation of the same, dilatation of the pupils.

Fractures of the lower cervical vertebræ as far down as the second dorsal vertebra, and complete transverse injury of the spinal cord, may cause paralysis of all four extremities as well as of the abdominal and intercostal muscles, bladder, rectum, etc. In consequence of paralysis of the intercostal and abdominal muscles, respiration is wholly diaphragmatic. Inspiration is carried on by the diaphragm and some of the cervical muscles, expiration by the elasticity of the thorax. Sneezing and coughing are impossible.

After fracture with injury to the upper and middle dorsal segments of the spinal cord, motor paralysis of the lower extremities is observed, and almost always of the abdominal muscles, bladder, and rectum. The anæsthesia resulting from paralysis of sensation reaches about to the region of the ensiform process, and is combined with a sense of constriction at the same level. Paralysis of the bladder causes retention of urine. Attention must be paid to this retention with a corresponding distention of the bladder. If the urine is not drawn off by means of a catheter, the bladder runs over, as it were—that is, incontinence of urine with constant trickling of the same ensues, a condition which is also called paradoxical ischuria, because the bladder remains full in spite of the flow of urine.

Paralysis of the intestines causes constipation with subsequent incontinence of fæces, or the latter may exist immediately after the injury. Tympanites results from stagnation of fæces and from gas, and is extremely distressing to the patient.

Fractures attended by injury to the cord close above the lumbar enlargement, in the region of the lower dorsal vertebræ, may give rise to motor paralysis of the lower extremities, the bladder, and the rectum, with anæsthesia of the skin reaching about to the umbilicus.

Increased reflexes are sometimes combined with all these paralyses that have already been mentioned, which appear as tonic or clonic spasms of the muscles in the paralyzed parts, because the fibres passing from the reflex-inhibiting centres in the cerebrum to the gray matter of the lumbar spinal cord are interrupted by all transverse injuries of the cord located above the same. These muscular spasms occur spontaneously or upon the slightest irritation—e. g., from touching the patient, from passing the urine, from the introduction of a catheter, in consequence of irritation from fæcal masses in the rectum, etc. This enhancement of the reflexes is, however, generally speaking, seldom observed, because an irritation of the reflex-inhibiting fibres may exist simultaneously. In case of complete transverse injury of the spinal cord, the superficial and deep reflexes usually disappear permanently, while in partial transverse injuries they are preserved (Bastian, Bolwby, Thorburn). The plantar reflex usually disappears last, later than the ankle clonus and patella reflex. Of the organic reflexes, those of the bladder and the rectum are often preserved even after complete transverse injury. The superficial reflexes return now and then after days or weeks or months.

In case of the transverse injuries of the spinal cord situated lower down in the middle of the lumbar enlargement, about on a level with the twelfth dorsal vertebra, an incomplete motor and sensory paraplegia is observed in addition to absence of the reflexes. There is motor paralysis of all the gluteal muscles which are supplied by the sciatic nerve and of the muscles of the posterior aspect of the thigh and the leg, with the exception of those supplied by the anterior tibial nerve, whose nucleus lies in the upper part of the lumbar enlargement, and also paresis or paralysis of the sphincter ani. If the injury of the spinal cord lies higher, in the upper part of the lumbar enlargement, the muscles supplied by the anterior crural, obturator, and anterior tibial nerves are also paralyzed. In fractures from the third lumbar vertebra down, the spinal cord as such can no longer be injured, as the apex of the conus terminalis ends at the second lumbar vertebra, and here passes over into the cauda equina. Injury of the latter results in paralysis of the lower limbs and the pelvic organs.

In the paralyzed portions of the body, especially in the region of the sacrum, the trochanter, the heel, the elbow, etc., bedsores very easily arise in consequence of the paralysis of sensation and trophic

disturbances, and these may, in unfavourable cases, rapidly increase in size.

If there is only partial injury of the transverse section of the spinal cord, there ensue corresponding partial paralyses in the regions supplied by certain nerves. If an entire half of the cross-section of the cord is destroyed, the symptoms of Brown-Séquard's unilateral lesion are observed—that is, motor paralysis of the injured half and sensory paralysis of the opposite part of the body (see page 757). If the spinal cord is in part preserved, the motor paralysis usually preponderates in comparison with the sensory disturbance, and the latter may, in the paralyzed limbs, for instance, be wholly absent or disappear, while the motor paralysis persists. This last fact is explained partly from the numerous anastomoses of the sensory cutaneous nerves, so that intact nerve tracts assume the conduction to the central organ in place of those that are injured, and partly from the course of the fibres in the spinal cord. Here also there are numerous anastomoses, and the fibres that enter the posterior columns of the spinal cord from the posterior roots do not all end at the same level, but in part connect higher up with the ganglionic cells. The reflexes are preserved (see page 770).

The vasomotor disturbances resulting from injury of the vasomotor nerves in the gray matter of the spinal cord and in the medulla oblongata are also of special interest. In consequence of paralysis of the vasomotor nerves, the tone of the vessels in the paralyzed parts is lowered and the circulation is retarded, especially in the capillaries, œdema arises, the secretion of sweat is diminished, etc. Priapism is in part the result of vasomotor paralysis, with marked congestion of the vessels of the corpora cavernosa of the penis, which are distended and lowered in their tone. Active erections of the penis, however, are impossible with simultaneous paralysis of the erection centre in the lumbar spinal cord. By giving the penis an elevated position, priapism can usually be easily overcome. In other cases priapism is conditioned upon irritation of the erection centre in the lumbar portion of the cord.

The appearance of sugar in the urine (diabetes) is a result of the injury of vasomotor nerve fibres. It occurs after every division of the spinal cord as far down as the level of the lumbar vertebræ, after injury of the superior and inferior cervical ganglia and the superior dorsal ganglion of the sympathetic nerve, after division of the sympathetic nerve, and especially after injury of the vasomotor centre in the medulla oblongata (see page 128).

Changes in the action of the heart and the pulse occur especially in connection with injuries of the spinal cord and its nerves in the region

of the cervical and upper dorsal vertebræ. Marked slowing of the heart's action arises from injury to the nervi accelerantes, which have their origin in the gray matter of the spinal cord and go with the sympathetic nerve to the heart. Pulse acceleration, on the other hand, is observed especially in connection with bilateral paralysis of the pneumogastric nerve and the nerve fibres originating from the spinal accessory.

Buchterkirch, Bumke, and others observed, after contusion of the spinal cord, multiple symmetrical tumours in different parts of the body—e. g., lipomata—and also circumscribed hypertrophy of the muscles.

Fig. 374.—Bony union of a fracture of the bodies of the sixth and seventh cervical vertebræ; the paralyses which existed at first gradually disappeared altogether so that the patient was able to move about easily and perform his work as a porter up to the time of his death (after Zöller and Sonnenburg).

In case of very extensive paralysis the body temperature often sinks very rapidly up to the time of death. In other cases of injury of the spinal cord, especially after fractures of the cervical vertebræ, and less often after those of the dorsal and lumbar vertebræ, the temperature of the body rises to 40°, 41°, and even 42° C. (104°, 106°, and 107° F.). It is conditioned upon an increased metabolism brought about by the central nervous system, in consequence of irritation of the vasomotor nerves. The amount of heat lost is diminished at the same time in consequence of the contraction of the cutaneous vessels from vasomotor irritation. Finally, the rise in temperature may be conditioned in compound fractures of the vertebræ upon microbic infection (see also Principles of Surgery, § 62, page 310, Fever).

The termination of a vertebral fracture depends mainly upon whether or not the spinal cord is injured, and if so, to what degree. In compound fractures infection of the wound is to be prevented by aseptic measures. The higher up and the more extensive the injury to the spinal cord, the more certain is death to ensue. The prognosis

of fractures of the cervical vertebræ is, however, more favourable than was formerly supposed, as the remarkable case reported by Zöller and Sonnenburg tends to show. Sonnenburg has collected from the literature of the subject nineteen cases of recovery from fractures of the cervical vertebræ. The prognosis is best if the fracture is below the origin of the phrenic nerve—that is, in the region of the fifth and the sixth vertebræ. The cases of recovery collected by Sonnenburg were all those of fractures of the cervical vertebræ below this point. Küster saw union of a fracture of the odontoid process of the axis. Lambotte found at the autopsy of a woman twenty-seven years old, who died of hæmorrhagic variola, a fracture of the base of the odontoid process of the axis which had united by the formation of fibrous tissue. The fracture had resulted from a simple extension of the head, the atlas was displaced somewhat forward, and the transverse ligament was intact. The position of the head was the same as that in torticollis. One year after the injury the symptoms of progressive paralysis made their appearance. The fatal termination often follows immediately after the traumatism, in consequence of the injury of vital parts of the brain and the spinal cord, from severe associated injuries (fracture of the skull, injuries of the thoracic and abdominal organs, etc.), and from shock. It may also occur later, after days or weeks or months, in consequence of the injury to the spinal cord and its results (progressive ascending and descending myelitis and neuritis, bedsores, with secondary sepsis, pyæmia or erysipelas, cystitis and suppurative nephritis after paralysis of the bladder, congestion of the lungs and of the brain, etc.). In compound fractures death may occur from suppurative inflammation of the spinal cord and its membranes (suppurative myelomeningitis). The paralysis may entirely disappear in mild cases. The prognosis of paralysis of the spinal cord and its nerves from compression is most favourable when the pressure resulting from the displacement of the fragments, for instance, can be overcome. Regeneration of the ganglion cells, or a reunion of severed fibres of the spinal cord, do not, according to our present knowledge, occur in man. The defect is permanent. Chronic invalidism often follows concussion and contusion of the spinal cord in consequence of chronic myelitis, as has been already mentioned. Death may suddenly occur here as soon as a chronic myelitis involves vital parts, especially the medulla (see also page 128, Injuries of the Brain and Medulla).

Fig. 375.—The same specimen as Fig. 374 after opening the spinal canal.

A vertebral fracture sometimes unites with marked displacement, and the existing paralysis gradually disappears, whether it be that the spinal cord adapts itself to the pressure or that the paralysis was conditioned upon compression from an effusion of blood into the vertebral canal and that this is absorbed.

The diagnosis of a vertebral fracture is often difficult and not infrequently impossible. The differential diagnosis is to be made particularly between fracture, distortion, dislocation, and an effusion of blood in the vertebral canal. A careful methodical examination of the patient is of great importance in making the diagnosis. If a patient, after a fall, remains immovable, is conscious, and there is no fracture of the limbs, one should think of fracture of the spine. The examination of persons thus injured must be made with the greatest care in order to avoid displacement of the fragments by unskilful movements. The patient may suddenly die in this way in consequence of compression of the spinal cord, especially in case of fracture of the upper cervical vertebræ. In order to get a sufficiently good view of the spine it may be necessary to cut the clothing open, etc. A fracture of the spine can often be recognised at once by the characteristic deformity (depression, angular kyphosis, lateral deflection, etc.). An examination should also be made of the interior of the pharynx in cases of fracture of the cervical section of the spine. The fifth cervical vertebra can usually be reached with the finger from within the mouth, and exceptionally the seventh also and the first dorsal (Waldeyer, Demme). It is also to be determined whether any paralysis of motion and sensation exists, and one should observe the condition of the pupils, the respiration, the pulse, the intestines (tympanites), the bladder, the urine (diabetes), etc. If there is paraplegia with paralysis of the bladder, the diagnosis of fracture of the spine with injury of the medulla is certain. If there is complete paraplegia we have to do with a compression or injury of the entire cross-section of the spinal cord, whereas partial paralysis is caused by a corresponding partial compression or injury of the same. If the paralysis first appears later on and not immediately after the injury, it is usually due to increasing compression from an effusion of blood in the vertebral canal. The symptoms of fracture are often so trivial that they may be easily overlooked.

The Treatment of Fractures of the Spine and Injuries of the Spinal Cord.—Patients with fractured spines must be transported and placed in bed with the greatest care. Every careless movement is to be avoided. The head, vertebral column, and back must be given a secure position. The same caution is to be used in removing the clothing of the patient. The best way is to lay the patient as horizontally as possible upon a hair mattress with a large water cushion or air cushion in the neighbourhood of the buttocks, in order that bedsores may be avoided. The elevating frame devised by Hamilton and Volkmann (Fig. 376) is very strongly to be recommended. By means of this device the patient can be raised without pain, for allowing defecation, for example. The fæces pass through the hole in the elevating frame into a bedpan placed beneath.

As regards the treatment proper of the fracture, the attempt should be made in suitable cases to overcome the existing deformity. This must be done very cautiously; a violent reduction of the displacement with the patient under an anæsthetic is always to be avoided. This is only allowable later, after weeks perhaps, if the displacement increases and the paralysis of the spinal cord continues. The best way is to attempt to overcome the deformity by gradual extension (Fig. 377). A well-padded sling is placed about the nape of the neck and the lower jaw, and a weight of two kilogrammes is at first attached to the extension cord, which is afterward increased. Counter-extension is secured by raising the head of the bed. In fractures of the dorsal segment of the spine permanent extension may be accomplished by placing a well-

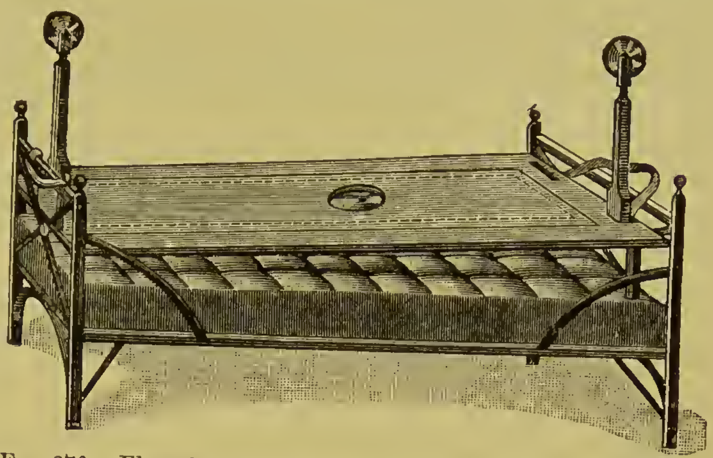


FIG. 376.—Elevating frame invented by Hamilton and Volkmann for fractures of the spine and pelvis.

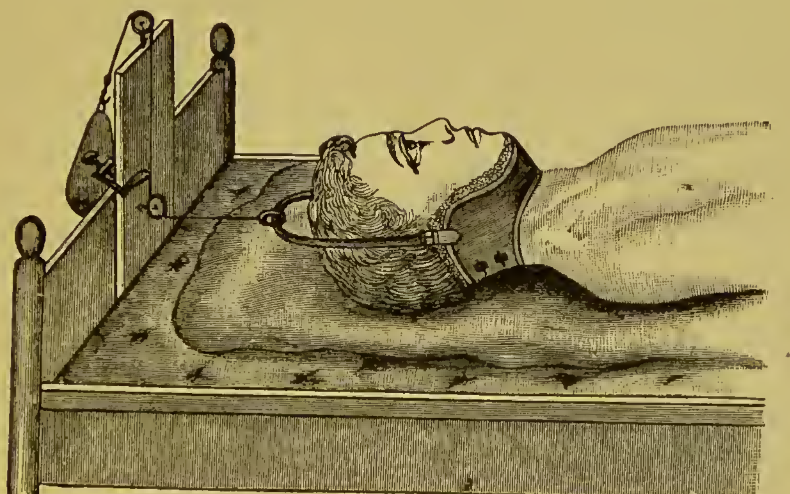


FIG. 377.—Weight extension for fractures of the spine.

padded roller cushion under the back or by placing the patient in a Rauchfuss's hammock (see Fig. 406, page 819). Several weeks later a jacket of felt or plaster of Paris, after Sayre, can be used, which enables the patient to leave his bed. This must not be done too

early, however, as the deformity may easily increase again. Regarding the preparation of felt and plaster jackets, the reader is referred to pages 807 ff. and 820 ff.

In suitable fresh cases one may also, after overcoming any displacement that there may be, apply a plaster-of-Paris splint in fractures of the cervical segment of the spine, for example, as represented in Figs. 411, 412, and 413, or supporting apparatus made of felt as represented in Fig. 415, or, finally, plaster-of-Paris jackets, etc., in fractures of the dorsal or the lumbar segment of the spine (see Fig. 396, page 809, and Fig. 407, page 820).

Operative interference in fresh fractures of the spine has been especially recommended by Cline, W. Thorburn, Tillaux, Leyden, White, Lane, and others. In suitable cases of simple as well as compound fractures the site of the fracture has been sufficiently exposed, the fragments raised by means of elevators, the sharp edges of the fractured bones chiselled away, and especially the vertebral arches removed (so-called laminectomy; see § 150, page 831). Few satisfactory results have as yet been obtained by this operative interference in fresh cases, but success has attended it in cases of badly united fractures with paralysis of the spinal cord caused by compression (see page 778). I do not doubt, however, that fresh cases of fracture of the spine will be more frequently operated upon in the future than has been the case heretofore, in view of the hopelessness of conservative treatment. In deciding whether to operate or not it is important to know whether the cord is compressed or crushed, but, unfortunately, this differentiation is in most cases clinically impossible. Especially in fractures of the vertebral arches, with depression of the fragments in the direction of the vertebral canal, one should cut down upon the arch in question and, without directly opening the spinal canal, lift up the arch by means of an elevator or by seizing the spinous process with stout bone forceps, or resect it. After resection of the arch, one may chisel away the projecting edge of the body of a vertebra in case reduction in fresh cases is impossible or the fracture has already united. Displacement of the body of a vertebra is very difficult to remedy by operative means, but it is possible, as is shown by a case reported by Church and Eisendrath. In this case there was a fracture and dislocation of the tenth and eleventh dorsal vertebræ, and the paralysis which had existed disappeared at once. In suitable cases one should retain the fragments in position by means of a silver-wire suture, or by winding silver wire about the spinous processes. Operation is also indicated in the case of comminuted fractures in which splinters of bone have been driven into the spinal cord. Péan extracted ten pieces

of bone which had been forced into the spinal cord. The patient recovered.

The treatment of compound fractures of the spine should conform to antiseptic principles, as given in detail in Principles of Surgery, § 101, page 597 ff. The reader is also referred to § 142, page 787 (Treatment of Gunshot Injuries of the Spine). In compound fractures the site of fracture should, in suitable cases, be sufficiently exposed, portions resected, splinters removed, etc.

In the further course of a vertebral fracture special attention is to be paid to preventing bedsores by seeing that the patient is properly placed in bed, by great cleanliness, by rubbing the skin with alcohol, etc. Unfortunately, when there is paralysis, all efforts are often in vain. In paralysis of the bladder, with retention of urine, the latter should be regularly drawn off by means of an aseptic metallic catheter. If incontinence of retention exists, with distention of the bladder and continuous flow of urine, the latter may be allowed to pass off into a bottle between the legs of the patient without the use of a catheter. If it is desired to introduce a permanent catheter into the bladder, a carefully disinfected soft-rubber one is used for the purpose, which is fastened by means of adhesive plaster or a suspensory bandage (see Surgery of the Bladder). Death of the patient in consequence of suppurative cystitis and pyelitis may be occasioned by unclean catheters. If there are symptoms of catarrh of the bladder, or of purulent cystitis, the bladder must be carefully irrigated once or twice a day, after evacuation of the urine, with boric acid (three per cent), permanganate of potash (one tenth of one per cent), salicylic acid (one third of one per cent), carbolic acid (one to two per cent), or bichloride (one hundredth of one per cent). This is best accomplished by means of an aseptic rubber catheter. Chlorate of potash is given internally with some caution. The constipation resulting from paralysis of the intestines, which is sometimes very marked, is treated by enemata, massage, and electricity. In the use of the latter a large electrode plate is placed upon the abdomen and a rod-shaped one is introduced into the rectum. In case of extreme tympanites resulting from intestinal gases which can not escape through the contracted sphincter ani, subcutaneous stretching of the sphincter is to be recommended (Hoffa). Cocaine is first injected hypodermically, and the sphincter is stretched as completely as possible with the two forefingers, and then with the forefinger and middle finger, and a stout India-rubber tube may then be passed into the rectum. The latter is often sufficient without stretching the sphincter. The paralyses are to be treated according to general rules by electricity and massage.

In case of old fractures of the spine with marked displacement and paralysis from pressure of the fragments, the question of the resection of the latter or of the vertebral arches may arise, as has been already mentioned. In paralysis of the spinal cord from compression very favourable results have been repeatedly secured by resection of the vertebral arches that compressed the cord, and chiselling away any projecting edge of the fractured body of a vertebra (Macewen, Lauenstein, Boyle, Boiffin, and others). After resection of the vertebral arches, the technique of which is given in § 150, page 831, permanent extension is applied in the manner described on page 775.

Urban performed osteoplastic resection of the vertebral arches for compression of the spinal cord by forming a flap of soft parts and bone, and then, after retracting the spinal cord to one side, chiselled away the projecting edge of the body of the vertebra. Finally, the spinal cord was replaced in its normal position, and the vertebral arches, together with the flap of soft parts, were sutured in place. Phelps likewise chiselled away with good results the projecting edge of the body of a vertebra that pressed on the cord after he had opened the vertebral canal by the resection of two spinous processes and two arches.

In the after-treatment, supporting jackets, massage, baths, electricity, etc., are often necessary in order to prevent atrophy of the muscles. For the preparation of felt and plaster jackets the reader is referred to page 807 ff. and page 820 ff.

§ 141. **Dislocations of the Spine.**—By vertebral dislocations is understood injury of the spinal column such that the articular processes of the vertebræ are permanently separated from one another either completely or incompletely. In dislocations of the spine the upper vertebra is designated as the dislocated one, contrary to the usage in dislocations on the extremities. Dislocations of the spine are often complicated by fractures, especially those of the articular processes. In diastasis or distortion of the vertebræ there is no permanent separation of the articular surfaces, but only a momentary one, inasmuch as reposition takes place immediately after the articular ligaments and the intervertebral disks have been put on the stretch or torn.

Dislocations of the spine are very rare. They usually involve the most movable portion—viz., the cervical vertebræ, and least frequently the lumbar vertebræ. Vertebral dislocations occur most frequently among men from twenty to forty or fifty years of age.

Dislocations of the spine arise from movements which overstep the physiological limit of a particular range of motion or from altogether abnormal and unnatural movements which are not possible in accordance with the

mechanical structure of the vertebral articulations that are involved. They are always the result of the action of great violence—e. g., a fall from a considerable height, the falling of heavy weights, being buried up in mines, etc. Vertebral dislocations from muscular action are only possible when the bone and the ligaments have lost their normal power of resistance in consequence of pathological changes.

With reference to their origin we may distinguish the following kinds of dislocation: First, dislocations by hyperflexion; second, dislocations by hyperextension (dorsal flexion); third, dislocations by abduction or rotation. Dislocations by hyperextension (dorsal flexion) are always, no doubt, combined with fracture of the vertebral arches and the spinous processes, with corresponding crushing of the spinal cord. Pure dislocations by extension scarcely come under clinical observation, as when they occur it has usually been from combined movements of the vertebral column.

The most frequent, and with reference to their mechanism the best understood, are the forward dislocations by hyperflexion and those by abduction or rotation, which, as has been said, occur most commonly in the cervical segment of the spine which is so movable.

1. The forward dislocations by hyperflexion, with rupture of the intervertebral disks and the ligaments between the arches, are the most common, and are often combined with avulsion of a portion of the bodies of the vertebræ and fracture of the articular surfaces. As a result of the hyperflexion the

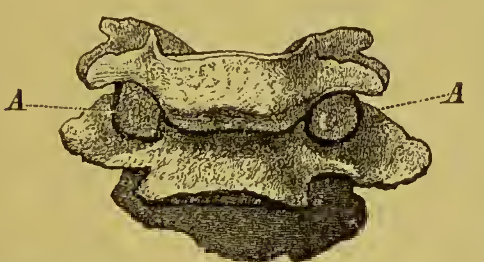


FIG. 378.—Complete dislocation of a cervical vertebra by hyperflexion: A, both articular processes have become displaced forward and locked.

FIG. 379.—Unilateral (left sided) dislocation of a cervical vertebra by abduction and rotation: A, the locked transverse process.

upper vertebra slides forward, the articular processes are lifted from one another, and, in consequence of a subsequent dorsal flexion, the separation of the articular processes becomes permanent—that is, the two lower articular processes are caught firmly in front of the upper ones of the lower vertebra, so that a complete anterior dislocation is the final result (Fig. 378). In this form of dislocation the transverse processes may break off, and, moreover, as has been mentioned, bone may be torn from the articular surface of the body of the dislocated vertebra or from the arches and the spinous processes by the action of the intervertebral disks and the ligaments.

2. Dislocations by abduction and rotation arise, in the cervical segment of the spine, for example, in the following manner: We take up the two dislocations together because the action of abduction and that of rotation are here combined, and we have already emphasized the fact (page 752) that in connection with every forced abduction a rotation takes place. We will

suppose that the head is approximated to the right shoulder (abducted from the median line of the body). The left transverse processes are then lifted somewhat from one another. If the movement of abduction, or by this time that of rotation also, is continued, the left transverse processes, of two cervical vertebræ, for example, may be permanently separated from one another, inasmuch as they utilize the bone on the right side between the two transverse processes and the vertebral arches as a fulcrum. By means, then, of forced abduction of the head to the right side with a movement of rotation, there occurs a left unilateral dislocation of the vertebra in question (Fig. 379). The locking of the articular processes, shown in Fig. 379, always occurs upon the side opposite to that on which the abduction takes place, but on the same side with the rotation. The locking is always unilateral. The transverse process upon the other side of the dislocated vertebra is also displaced, of course, and in a backward direction, but it is never locked as upon the side of the dislocation proper. In consequence of forced rotation, however, the transverse process of the upper (dislocated) vertebra may be pushed so far backward on the side that is not locked, that the two transverse processes are no longer in contact, and the articular process of the dislocated vertebra rests upon the transverse process of the lower vertebra. This dislocation has been called bilateral dislocation in opposite directions. The dislocation of one side with locking of the articular processes is conditioned mainly upon abduction, the displacement on the other side upon rotation of the vertebra only.

The other injuries attending dislocations of the spine consist, in the case of forward dislocations by flexion, especially in rupture of the check ligaments, the intervertebral disks and the ligamenta flava, and in avulsion of the articular processes and portions from the lower and anterior surface of the dislocated vertebra. In dislocations by abduction and rotation the fulcrum—i. e., the transverse process upon the side that is not dislocated—often breaks. In bilateral dislocations in opposite directions both articular processes may break off. The very strong anterior longitudinal ligament is usually preserved. The effusion of blood is, as a rule, rather marked. It sometimes spreads out between the muscles. The injury of the spinal cord is essentially the same as in fractures. It consists partly in compression from effusion of blood and from displacement of the bones and partly in contusion, crushing, and laceration, with immediate death it may be. Injuries of the spinal cord are not so frequent in dislocations as in fractures, while, on the other hand, the crushing of single nerves of the cord is more frequent in the former. Injuries of the spinal cord occur least often in dislocations of the cervical vertebræ.

The symptoms of dislocations are much the same as those of fractures. The noticeable rigidity of the parts at the site of injury is usually characteristic of dislocations, and can only be overcome by very definite movements of reduction. The kyphosis which is usually present in fractures is not so pronounced in dislocations. In the latter, one observes abnormal rotation, abduction, and slight flexion. The spinous process of the dislocated vertebra is depressed and can be

scarcely felt, if at all, because it is displaced in a forward or lateral direction. The next spinous process, therefore, apparently projects. In dislocations involving the cervical segment of the vertebral column the position of the head is very characteristic (see Figs. 380, 381). The nerve symptoms on the part of the spinal cord are slighter, as has been said, in dislocations than in fractures. There is usually only injury to the spinal nerves on the dislocated side.

Fig. 380.—Double dislocation forward by flexion in the region of the fourth to the seventh cervical vertebræ.

The course and the prognosis are more favourable in simple dislocations than in fractures. Any symptoms of paralysis that may exist on the part of definite nerves or of the spinal cord are conditioned mainly upon their being compressed or dragged upon, and often disappear immediately upon successful reduction of the dislocation.

The treatment of dislocations consists in their reduction as soon as possible, and this should be done with the aid of an anæsthetic in order to overcome the resistance of the muscles. These attempts at reduction are to be conducted with great caution in order that the spinal cord may not be crushed. Paralyses have developed after reduction of a dislocation in consequence of crushing of the spinal cord. In all cases in which reduction of the dislocation does not succeed and there are symptoms of compression of the spinal cord, operative treatment should finally be tried—that is, the dislocation should be cut down upon and the obstacle to reduction overcome as far as possible. Chipault prefers operative measures in all cases except in dislocations of the cervical vertebræ and in severe injury of the cord. In old dislocations with paralysis of the spinal cord from compression, resection of the spinous processes and the vertebral arches may be indicated.

As the symptomatology and treatment of dislocations depend very essentially upon their location, the better way will be for us to take up dislocations of the different segments of the vertebræ in their order.

1. **Dislocations of the Occiput** (from the atlas) are very rarely found in the living. Only two certain cases have been observed as yet of incomplete backward dislocations of the occiput. The ligamentous apparatus of the articulation between the occiput and atlas, which has great power of resistance, is ruptured only by the action of very great violence, and death almost always then follows from injury of the spinal cord, especially from paralysis of respiration. Unilateral dislo-

cations may be produced experimentally by direct pressure toward one side.

If a dislocation of the occiput should come under treatment, one would, in case it were a dislocation backward or forward, attempt its reduction by traction upon the head and pushing it backward or forward. In case of unilateral dislocation, one would extend and rotate the head toward the dislocated side.

2. **Dislocations of the Atlas** (from the axis).—The atlas, as is well known, executes rotatory movements about the odontoid process of the axis. The two vertebræ are firmly bound to one another by ligaments (ligamenta alaria, cruciform ligaments, suspensory ligament, and transverse ligament). Dislocation of the atlas from the axis is only possible in case of fracture of the odontoid process or rupture of the transverse ligament, by which the odontoid process is firmly held.

Forward dislocation of the atlas is the most common. This results from hyperflexion of the head, with rupture of the ligaments of the atlas by the odontoid process of the axis, which is forced backward. The head is correspondingly bent forward.

A traumatic backward dislocation of the atlas has, according to Hoffa, not yet been observed or described.

Dislocation of the atlas by abduction or rotation is always unilateral. If the dislocation is on the right side the head is turned to the left, and *vice versa.* Bilateral dislocations in opposite directions occur here also.

The injuries to the cord in connection with dislocations of the atlas by hyperflexion are usually severe and fatal, whereas in unilateral dislocations by rotation they are milder. There have been individual cases of the latter in which successful reduction, followed by the complete recovery of the patient, is said to have been accomplished.

The question of treating dislocations of the atlas only arises in connection with unilateral dislocation by abduction and rotation. The treatment consists in reduction by traction upon the head and rotation toward the dislocated side.

3. **Dislocations of the other Cervical Vertebræ.**—Of dislocations of the remaining cervical vertebræ, those between the fourth and the fifth and between the fifth and the sixth are the most frequent. Forward dislocations arise mainly from hyperflexion of the head—e. g., from a fall, from being buried up, from a blow, etc. They are usually combined with rupture of the intervertebral disks and the stretched ligaments (ligamenta flava) on the vertebral arches and the spinous processes. The articular processes of the upper, dislocated vertebra come to lie in front of those of the lower one (see Fig. 378).

The symptoms of this forward dislocation of the cervical vertebræ are similar to those attending transverse fractures of a cervical vertebra with forward displacement of the upper fragment (Fig. 380). The head is bent forward, the chin approaches the sternum and is not infrequently held fast by the patient with both hands, in order to avoid painful movements. The cervical segment of the spinal column is bent at a slight angle (kyphosis), the spinous processes from the dislocated vertebra upward can scarcely be felt, if at all, and the muscles of the nape of the neck are spasmodically contracted and prominent. Swallowing is difficult, and one often feels the projecting vertebra beneath the mucous membrane of the pharynx. The lumen of the vertebral canal is very much encroached upon and the spinal cord is usually severely crushed, so that death from respiratory paralysis, due to paralysis of the phrenic nerves, usually follows immediately or soon after the injury, especially in case of dislocation of the third and fourth cervical vertebræ. If the patient lives, severe paralysis of the limbs and the trunk usually persists.

The treatment of dislocation of the lower cervical vertebræ consists in attempting reduction with the patient under an anæsthetic. Hueter and Hoffa properly recommend that the patient's friends should be distinctly warned that the attempt at reduction is likely to be unsuccessful. Reduction is, under certain circumstances, dangerous to life, and should therefore be executed with great caution. Hueter recommends that it be done in the following manner: The dislocation should be changed, to begin with, into a unilateral dislocation by rotation. This is done by inclining the head toward the left shoulder, and thus raising the locked transverse process on the right side. The transverse processes on the right side are then brought into their normal position by turning the head backward so that the right ear moves in a backward direction. The reduction of the unilateral (left-sided) dislocation which still remains is then accomplished by executing precisely reversed movements—that is, inclining the head to the side that is not dislocated (right) and turning it backward so that the left ear moves in a backward direction.

Dislocations of the lower cervical vertebræ backward by forced dorsal flexion with other movements are scarcely ever observed, as has been said, in the living. The head and the upper part of the neck would be bent backward and the face turned upward. The soft parts of the neck would therefore be more or less tense in front, with a noticeable angular bend in the nape of the neck. Reduction would be undertaken by extension and counter-extension with the patient under an anæsthetic.

Unilateral dislocations of the lower cervical vertebræ by abduction and rotation are usually brought about by a fall upon the head or by forced rotation of the neck. As is apparent from Fig. 379, the head in this unilateral dislocation by abduction and rotation is inclined toward the sound (not dislocated) side and is fixed in this position (Fig. 381). The chin is not drawn to the opposite side, as in physiological abduction (see above, page 752), but occupies the median line, because the locked (dislocated) transverse process of the upper vertebra is pushed forward. The transverse processes lie sometimes simply one above another. The line of the spinous processes is only slightly changed—that is, it deviates but little. On the non-dislocated side the neck posteriorly is fuller and more tense. The act of swallowing is interfered with and the abnormal projection of the dislocated vertebra may be felt with the finger in the pharynx. The nervous disturbances are either conditioned upon concussion, compression, or contusion of the spinal cord, or upon crushing of the nerve roots at their place of exit upon the dislocated side, or sometimes also upon excessive traction on the same on the side that is not disloeated. The prognosis depends here also mainly upon the degree of the existing injury to the cord, just as in fractures.

FIG. 381.—Unilateral (right-sided) dislocation in the region of the fourth to the seventh cervical vertebræ.

In bilateral dislocations in opposite directions the position of the head is essentially the same as in unilateral dislocation, save that besides being inclined to the side of the vertebra that is not locked it is rotated still more, so that the ear on this side is moved forward.

Reduetion must be undertaken here also with the greatest possible caution under an anæsthetic. It is accomplished by the same movement as those by which it was produced—that is, hyperabduction and rotation. The head should be inclined still more to the side to which it is already inclined and then rotated so that the ear on the dislocated side moves forward and the other backward. When the transverse processes are locked—e. g., on the left side—the head, which is inclined to the right, is drawn still nearer to the right shoulder, whereby the locked transverse process on the left becomes free, and by turning the left side of the head backward the left articular process

slips back into its normal place, the right transverse process serving as a fulcrum. If the transverse processes are not locked in the way shown in Fig. 379—that is, if the dislocated articular process lies not in front of the articular process of the lower vertebra, but upon it—it is sufficient to produce traction on the head and the upper cervical vertebræ, abduct the head toward the opposite side, and then rotate the head toward the dislocated side. If one should here incline the head still more toward the sound shoulder a complete locking of the transverse processes might occur and the articular process of the upper vertebra come to lie in front of that of the lower vertebra. Walton, after experimenting on cadavers, recommends the latter method of reduction for all unilateral dislocations of the cervical vertebræ by abduction.

In all movements for the reduction of dislocations of the lower cervical vertebræ one should grasp not only the head, but also the upper not dislocated cervical vertebræ.

4. **Dislocations of the Dorsal Vertebræ.**—Inasmuch as the dorsal vertebræ are firmly connected not only with one another, but also with the ribs, dislocations of the same without fracture are very rare. Pure dislocation of the twelfth dorsal vertebra is the most frequent, especially in a forward direction, by flexion of the vertebral column. It is less frequently unilateral, by abduction and rotation. In dislocation forward of the dorsal vertebræ the dislocated vertebra and its spinous process are depressed, as well as the underlying vertebræ and spinous processes which are pushed forward with it. The vertebral column has an angular deformity, and the spinous processes just above the dislocation are prominent. The distinction between fracture and dislocation is especially difficult in the dorsal and lumbar segments of the spine.

Reduction in forward dislocations by flexion consists in extension and counter-extension on the pelvis and in both axillæ, with pressure upon the projecting vertebra.

5. **Dislocations of the Lumbar Portion of the Spine** are very rare, on account of the position of the articular processes and the firm union of the lumbar vertebræ. Forward and backward dislocations and unilateral dislocations by abduction and rotation have been observed in individual cases only, the latter, however, being always attended with fracture of the articular processes. All these dislocations have been confined to the upper three lumbar vertebræ, which are the most movable. Injury of the spinal cord is possible only in case of dislocation of the first and second lumbar vertebræ, as the cord ends on a level with the latter and here passes over into the filum terminale and the cauda equina.

The symptoms of dislocation of the lumbar vertebræ are analogous to those of dislocation of the dorsal vertebræ, and reduction is accomplished, in accordance with the same principles, by extension and counter-extension and direct pressure upon the projecting lumbar vertebræ.

§ 142. **Gunshot Injuries of the Spine and the Spinal Cord.**—The course of a gunshot injury of the spine depends upon whether or not the vertebral canal is opened and the spinal cord is injured. If the spinal column is struck from in front, the ball often remains lodged in the body of a vertebra. When struck from behind or from the side, the spinous processes and the vertebral arches alone can be shattered without the vertebral canal being entered and the spinal cord injured. More frequently, however, the vertebral canal is opened in gunshot wounds of the spine, with more or less injury to the spinal cord. The cord is injured in part by the ball and in part by splinters of bone. As in gunshot wounds of the brain, the spinal cord may be greatly shattered by the splinters of bone. In other cases it is merely compressed by an effusion of blood, a fragment of bone, or the ball, without being directly injured. The deformity of the spinal column is less, generally speaking, in gunshot injuries than in indirect fractures.

The prognosis of an injury to the cord is not so favourable in gunshot wounds as in injuries inflicted by sharp weapons. It is most favourable when the paralysis is conditioned upon an effusion of blood or upon splinters of bone which have forced their way in and which can be removed. Paralysis, also, caused by pressure of the ball and displaced fragments of bone, has not, generally speaking, an unfavourable prognosis. The spinal cord seems in such cases gradually to accustom itself to a certain degree to the pressure of the ball that has healed up in the vertebral canal and of the displaced fragments of bone, and the paralysis accordingly disappears to a greater or less degree, and sometimes altogether.

Aside from the extent of the injury to the cord, the further course depends upon whether aseptic healing follows or suppuration extends to the vertebral canal, the spinal cord, and its membranes. This suppuration, or cellulitis, involves mainly the loose connective tissue between the vertebral canal and the dura; also the venous sinuses, the membranes of the spinal cord, and the cord itself. Circumscribed abscesses in the cord are formed especially around foreign bodies that have penetrated it. Suppurative spinal meningitis may spread to the membranes of the brain, so that the autopsy discloses a suppurative cerebral meningitis also. There is sometimes no continuous connection between the suppurative meningitis of the spinal cord and that of

the brain, because the micro-organisms and their toxines have been transported through the lymph passages and by metastasis have caused a cerebral meningitis. As we saw when treating of compound fractures of the skull, a cerebral meningitis can, in the course of one or two days even, involve the entire vertebral canal.

Death follows either in consequence of the injury to the spinal cord, especially the medulla and the upper portion of the cervical segment of the cord, or in consequence of the septic inflammation of the vertebral canal and its contents which has just been mentioned, or, finally, from chronic myelitis and its consequences—that is, from the ascending and descending myelitis and neuritis originating at the injured portion of the cord—and from other secondary diseases occurring in the further course of the injury (bedsores, cystitis, nephritis, etc.). Injury to the vertebral artery is also to be feared in gunshot wounds of the cervical portion of the spinal column.

The treatment of gunshot injuries of the spine and the spinal cord consists in disinfection of the wound after it has been sufficiently enlarged. This antiseptic treatment of gunshot wounds of the spine, in which the vertebral canal is opened and the spinal cord is injured, has its difficulties, it is true, and can not usually be carried out with sufficient thoroughness. The ball is only removed when it can be felt or seen—in short, when it is accessible. Too long a search for it is here also to be avoided. In searching for the ball, a magnetic needle or Trouvé's electric apparatus may be used with advantage. Completely detached splinters of bone and fragments of bone that press on the cord are likewise removed. It is better, in gunshot injuries, to leave the external wound open, pack it with iodoform gauze, and then cover it with an antiseptic protective dressing. If suppuration of the vertebral canal and its contents is averted, and if the injury to the spinal cord is not serious, recovery will follow with more or less nervous disturbances. For the successful treatment of the paralysis that may exist, it is especially important to determine its causes as far as possible—whether, for example, it is conditioned upon direct injury of the cord by the ball, or splinters of bone, or upon pressure from the ball or fragments of bone, etc. In suitable cases the effort will be made to remove by an operation the foreign bodies or the fragments of bone that press on the cord—e. g., by resection of the vertebral arches (see § 150). If paralysis and convulsive contractures persist, it is probable that splinters of bone have healed up within the spinal cord (H. Fischer). It is especially in gunshot fractures of the spine that operative treatment is indicated. According to Vincent, of thirty-three such fractures, eight were operated upon. Of these patients, five

recovered and three died. Of the twenty-five patients who were not operated upon, only six recovered and nineteen died.

§ 143. **Isolated Injuries of the Spinal Cord** without injury to the spine (without fracture and dislocation) consist especially in concussion of the spinal cord, which we have already mentioned (page 767). From a fall, from the falling of heavy weights, from a blow, in connection with railway accidents—e. g., derailments, or the collision of two trains, etc.—severe concussion of the spinal cord may ensue, just as we saw in treating of concussion of the brain. The term "concussion" is made by many authors very comprehensive, but Leyden distinguishes between shock and concussion proper of the spinal cord. As in concussion of the brain, so after that of the spinal cord, fatal paralysis may ensue immediately or speedily. Death is frequently, to be sure, conditioned upon simultaneous concussion of the brain and the medulla (see § 13). We leave this, however, out of the question here, and occupy ourselves chiefly with concussion of the spinal cord. In a fatal case of concussion of the spinal cord the autopsy reveals either direct laceration of the substance of the cord in different parts, with corresponding hæmorrhages besides extravasations of blood in the vertebral canal, or, on the other hand, in cases of pure concussion of the spinal cord, there are absolutely no gross or microscopic changes (Watson), precisely as in cases of pure concussion of the brain. In the case of persons who died after from two to eight months, or later, in consequence of concussion of the spinal cord, Schmaus found traumatic degenerations (circumscribed areas of softening, gliosis with cavity formation and fibrous degeneration in the medulla). In concussion of the spine produced experimentally in animals, Schmaus proved the existence of conditions similar to those just mentioned as occurring in man, or the beginning of the same. Upon microscopic examination he found as the real cause a direct traumatic necrosis of the axis cylinders, which may be followed by a more or less extensive softening of the supporting tissue. The nerve fibres that have perished in consequence of the concussion can not be sufficiently recognised with our present facilities, and more of them have often died than we can know. The cases are explained in this way, in which there are marked clinical symptoms with only apparently slight anatomical changes.

If the patient lives, the further course after concussion of the spinal cord is very varied. Recovery sometimes follows with striking rapidity. But in all cases of concussion of the spinal cord, especially when there are effusions of blood within the same, chronic myelitis is always to be feared. This is analogous to the chronic encephalitis which we have described in detail in connection with concussion and contusion

of the brain (see §§ 13, 17). Those cases which Erichsen first, and then Page and others have described, under the name "railway spine," come in this category. As the name implies, these concussions of the spinal cord occur in railway accidents, in consequence of the collision of two trains or derailment (see below, and page 790). Gussenbauer thinks that it is not the concussion of the spinal cord as such, but the lesion of the cord due to the extravasations of blood, that are the real cause of the spinal manifestations; the size and extent of these extravasations of blood decide whether a traumatic myelitis, with all its sequelæ, or a complete *restitutio ad integrum* will result. Manley, on the basis of fifty autopsies of persons dying from severe injuries of the spine and spinal cord, holds the opposite view, and thinks that intramedullary hæmorrhages are extremely rare.

The symptoms of concussion of the spinal cord and of railway spine—so-called traumatic neurosis (see page 790)—are at first of a shocklike nature, with striking manifestations of depression. Then follows permanent or, in case of severe concussion, only temporary improvement. One observes, in the further course of cases of the latter kind, very manifold disturbances, resulting from chronic myelitis, such as phenomena of irritation, pain, particularly in the muscles, conditions of excitation, overactivity of the senses, defective energy of movement, loss of memory, sometimes anæsthesia, sometimes hyperæsthesia, etc. Finally, convulsions and paralysis supervene. The course of such cases of traumatic neurosis is very chronic, and the probability of recovery is extremely small. The rule is, that chronic invalidism develops more and more. It is always to be borne in mind that in case of severe concussion of the spinal cord a concussion of the brain has usually taken place simultaneously, and that there also the corresponding secondary conditions are constantly developing more and more. Besides these cases that gradually grow worse, there are others in which severe paralysis immediately follows the accident and the latter is not infrequently immediately followed by death, in consequence of concussion of the spinal cord and the brain.

Railway Injuries.—The severest and most numerous injuries are observed from a collision of two railway trains. Tardieu, Erichsen, Page, Vibert, and others have made valuable reports of their observations in this direction, especially Vibert, who has given a report relating to four hundred persons injured in a railway accident at Charenton. Passengers upon the train which is moving most rapidly always suffer the severest and the most numerous injuries. Upon the head chiefly, and the upper part of the body of those who die at once, without external injury, one finds numerous punctate hæmorrhages, much as in fractures of the base of the skull. Severe fractures and injuries of the soft parts occur on the lower limbs, particularly in case those

injured have not protected themselves by rising early enough from their seats. There are not infrequently injuries of the lungs (hæmoptysis) from contusion or concussion of the thorax, and injuries of the abdominal organs also. The patients very frequently suffer serious disturbance of the general health or the central nervous system (insomnia, headache, alteration of mind, partly of an excited and partly of a melancholic, depressed type, disturbances of digestion, loss of memory with or without gaps [words, numbers], speedy mental weariness, oversensitiveness to stimulants, etc. [alcohol, tobacco], maniacal conditions, subjective auditory sensations, photophobia, paralysis of accommodation, disturbances of smell and taste, paræsthesia of the sensory nerves, anæsthesia, particularly in connection with organic injury of the brain, muscular tremor, motor weakness, particularly in the legs, paralysis, disturbances of circulation and respiration, increasing cachexia). The typical picture of paralytic dementia sometimes results. This entire complex of nervous symptoms is included under the name traumatic neurosis, which may occur after concussion of the brain and the spinal cord, even when caused by comparatively slight accidents. If the disturbances are not of an extreme nature, such patients are often wrongly accused of simulation. The records of law courts can give the story of many a case of this kind. In severe cases the prognosis of such concussions of the brain and spinal cord is unfavourable. If in two or three months after the injury there is not a steady improvement, there often ensues a chronic lesion, especially of the cerebral cortex, less often of the spinal cord. The spinal symptoms are mostly of a cerebral nature. English physicians, as was mentioned above, have designated the secondary diseases of the central nervous system after railway accidents as railway spine.

Traumatic Neurosis.—The so-called traumatic neurosis (railway spine of the English) occurs after concussion of the brain and spinal cord in consequence of a fall, in connection with railway accidents, from a severe contusion, blow, etc. It is of great clinical interest. Such patients, as has been said, are too often wrongly accused of simulation. The course is something as follows: Immediately after the accident there are often symptoms of shock with marked manifestations of depression. Then permanent or only temporary improvement gradually begins. In the most unfavourable cases one observes in the further course very manifold disturbances, such as conditions of excitation, pain, hypersensitiveness of the senses, defective energy of movement, loss of memory, sometimes anæsthesia and sometimes hyperæsthesia, convulsions, paralysis, etc. The prognosis of pronounced traumatic neurosis is often very unfavourable. Chronic invalidism develops only too easily. The treatment of traumatic neurosis is really the task of neurologists. Albin Hoffman has properly called attention to the fact that, since the adoption of legislation for insurance against accidents, traumatic neurosis has strikingly increased in frequency, and that it occurs as a genuine disease among persons who were before perfectly well much less frequently than has been heretofore supposed. In consequence of the legislation alluded to, simulation and traumatic hysteria have increased. It is in fact, in the majority of cases, a psychosis and neurosis which is not dependent upon a material change in the central nervous system—that is, a form of hysteria, as has been emphasized especially by Strümpell and Char-

cot and his pupils. In a small number of severe cases, however, progressive changes in the central nervous system in consequence of the concussion caused by the accident really exist, as Oppenheim and others have also recently stated, and as we have described them (pages 788, 789).

Compression of the Spinal Cord.—We have already (pages 768 ff.) spoken of compression of the spinal cord resulting from an increasing extravasation of blood, and that arising in connection with fractures and dislocations of the spine. If the case is one of compression of the spinal cord by an extravasation of blood exclusively, the spinal cord and the bone not being otherwise injured, there are usually no manifestations of paralysis immediately after the traumatism. They appear only later, when the effusion of blood has attained such a size that it exerts a real pressure upon the spinal cord. One then usually finds paraplegia, the prognosis of which, however, is altogether favourable if it is really caused exclusively by the extravasation of blood. After absorption of the latter, complete recovery may ensue. As has already been said, the pressure acts not only locally upon the spinal cord, but also as an obstruction to the circulation, with dilatation of the central canal of the spinal cord and saturation of the gray matter with serum or lymph. In consequence of this disturbance of circulation, necrosis and complete absorption of tissue may take place in the gray matter of the spinal cord with the formation of clefts and cavities (P. Rosenbach, A. Schtscherback). In such cases corresponding permanent disturbances remain. With reference to the symptomatology of compression arising from fractures and dislocations of the vertebræ, the reader is referred to page 768 ff.

Contusion of the Spinal Cord.—If the spinal cord has been directly injured in one or several places by a traumatism, there ensue immediately after the accident corresponding manifestations of paralysis, the prognosis of which is unfavourable, since we have seen that in man a regeneration of the injured portion of the spinal cord is at least doubtful. In the most severe cases the cord is lacerated or crushed to pulp. We have already described the symptomatology and the treatment of injury of the spinal cord (pages 767 and 774 ff.). I will only mention in addition that König, in a case of chronic traumatic myelitis, stretched both sciatic nerves with advantage.

Wounds of the Spinal Cord occur usually from puncture with a knife, a dagger, or a spear. The weapon that injures the cord either passes between the vertebral arches, or, less frequently, through the bone. Punctured wounds of the cervical portion of the spinal column are the most frequent. Depending on the injury to the cord, one observes either paraplegia, hemiplegia, or only localized paralysis in the

regions supplied by the severed nerve fibres. Very striking recoveries have been observed after punctured wounds of the spinal cord, and it is probable that in such cases the paralysis was conditioned more upon contusion and compression of the cord from an extravasation of blood, and that it was not due to the severing of a large number of nerve fibres. If only a few fibres have been divided by the puncture, the disturbed condition may be taken up by collateral intact tracts. Brown-Séqnard, Lotzbeck, and others observed punctures in the region of the nape of the neck followed by immediate paralysis of all four extremities, and within a few weeks the paralysis disappeared again in great measure. H. Fischer and Prestat saw comparatively speedy full recovery after puncture in the back between the sixth and seventh or between the tenth and eleventh dorsal vertebræ, with paralysis of the lower extremity and of the bladder.

Death results in part from injury of vital areas, especially in the upper portion of the cervical cord, and partly from suppurative meningitis in consequence of microbic infection of the vertebral canal and its contents. Secondary ascending and descending neuritis or myelitis plays here also an important part in the later course, and death may be occasioned thereby as soon as vital areas of the central nervous system, especially the medulla, are attacked by this ascending neuritis.

For the diagnosis of a penetrating wound of the spinal cord the escape of cerebro-spinal fluid is especially important, as are also the immediate appearance of paralysis and the location of the external wound. Probing such wounds is to be avoided as far as possible, or, at all events, only strictly aseptic probes should be used.

The treatment of wounds of the spinal cord is to be carried out in conformity with general, strictly aseptic principles. The wound is carefully disinfected, punctured wounds are enlarged, any foreign bodies that are present are to be removed, etc. The external wound may be drained and closed by suture, or left open and packed with iodoform gauze or bichloride gauze. The treatment of any paralysis that may be present is of a symptomatic nature (see page 774 ff., Fractures of the Spine with Injury of the Spinal Cord).

For diseases of the spinal cord the reader must be referred to treatises upon internal medicine, especially the neuropathological works of Leyden and Erb.

§ 144. **Curvatures of the Spine.**—In considering the etiology of curvatures of the spinal column it is necessary to understand the physiological mechanism of the vertebral column, our knowledge of which has been especially advanced by the Weber brothers, H. Meyer,

and W. Henke. We have already treated the subject briefly (page 751 ff.).

In the infant, as is familiarly known, the vertebral column is not curved, but forms a straight line. Gradually, as the child begins to sit, the spine develops a fairly symmetrical posterior curve, in consequence of the weight supported. Later, from the same cause and from muscular action in walking and standing, the permanent physiological curvature of the spine results. In consequence of the altered pelvic inclination in standing and walking, an anterior curvature of the lumbar segment of the spine is developed—in other words, a lordosis of the lumbar segment. To restore the equilibrium the dorsal segment must bend backward in an opposite direction by way of compensation, and the cervical segment in the opposite direction again, or forward. The curvature of the dorsal segment of the vertebral column is due also to the action of the respiratory muscles and the movements of the upper extremity (Buscalioni). In consequence of this normal S-shaped curvature, the spine is much more elastic and movable than would be the case if it formed a straight line. The abnormal (pathological) curvatures of the vertebral column also arise mainly in consequence of the weight supported. The development of such curvatures is especially favoured by injuries to the vertebræ and pathological processes, such as inflammations, abnormal (rhachitic) softness of the bones, abnormal growth on the part of the bones, by weakness of the muscles, etc. The physiological curvature of the spine also plays a very important part in the development of scoliosis (Schulthess).

The following pathological curvatures of the spine are distinguished: 1. Kyphosis (posterior curvature). 2. Lordosis (anterior curvature). 3. Scoliosis (lateral curvature). These curvatures appear either by themselves or in combination with one another. They are very rarely congenital, but much more frequently acquired, partly in consequence of the weight that is supported, partly from injuries and pathological processes of the most varied nature. The curvatures due to the superimposed weight are to be distinguished etiologically from those resulting, for example, from fractures or diseases of the vertebræ with corresponding defects, etc. From a therapeutic standpoint all mobile curvatures are more favourable than deformities that have already become fixed or stationary.

§ 145. **Scoliosis.**—By scoliosis (Figs. 382–384) (from σκολιόω, to curve, to bend) is understood a lateral bending and curvature of the vertebral column. The spine is seldom curved as a whole (complete scoliosis), but usually only a portion of it, especially the dorsal and lumbar segments. The convexity of the curvature is sometimes to the

right and sometimes to the left. In scoliosis a rotation of the vertebral column is always associated with its lateral bending (see Figs. 383 and 384). We saw above that in the normal abduction of the spine there is always a rotation of the same about the long axis. This rotation of the vertebral column always increases in scoliosis, because under the influence of its load the bodies of the vertebræ, being the thicker, are forced more and more into the convexity, which offers more room, and the thin vertebral arches into the concavity of the laterally bent spine, and the more so the more lax and extensible the ligamentous apparatus is, especially the anterior longitudinal ligament.

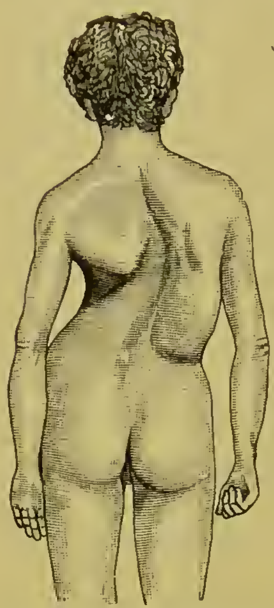


Fig. 382.—Right-sided scoliosis of the dorsal segment of the spine.

Scoliosis occurs very frequently, especially among girls during the latter period of their growth. Scoliosis of the dorsal segment of the spine (dorsal scoliosis) on the right side is the most common, for the reason, perhaps, that the dorsal segment, even under normal conditions, inclines very slightly toward the right. This physiological right-sided curvature of this part of the spine is probably conditioned upon the predominating activity of the muscles of the right shoulder and the right arm, and upon the left-sided course of the aorta (Sabatier, Bouvier). I must, however, agree with Adams, Lorenz, and others in the opinion that this right-sided "physiological" dorsal scoliosis, which occurs at about the seventh year, is by no means so regularly observed. In addition to right-sided dorsal scoliosis, primary left-sided lumbar scoliosis is also rather common.

If young rhachitic children from one to three years old have scoliosis, it is most frequently a symmetrical, complete scoliosis of the entire vertebral column, with the convexity upon the left side.

Development and Causes of Scoliosis.—The following forms of scoliosis may be distinguished, according to its cause: Congenital scoliosis, rhachitic scoliosis in early childhood, habit scoliosis, static scoliosis, traumatic scoliosis, and pathological scoliosis resulting from disease of the spine and the thorax (cicatricial contractions, paralysis, disease of the vertebræ, empyema, etc.).

Habit scoliosis, static scoliosis, rhachitic scoliosis, and pathological scoliosis are the most important and the most common forms.

1. Congenital scoliosis is very rare. It represents merely a congenital malformation or deformity of the vertebral column.

2. Rhachitic scoliosis occurs especially among rhachitic children from one and a half to four years of age. It is usually, as has been said, a left-sided, complete scoliosis, and is often combined with a slight posterior curvature (kyphosis). This early rhachitic scoliosis, or kypho-scoliosis, is not due alone to the softness of the rhachitic bones and the reduced power of resistance of the ligaments, the intervertebral disks, and the weak muscles, but also to the weight supported by the vertebral column, just as in habit scoliosis in later youth. Rhachitic children sit up too much and are carried about too much. Why is this rhachitic scoliosis of little children so frequently left-sided? In explanation of this fact it has been called to mind that children are carried chiefly upon the left arm of their nurses, so that the spine is bent to the left continuously.

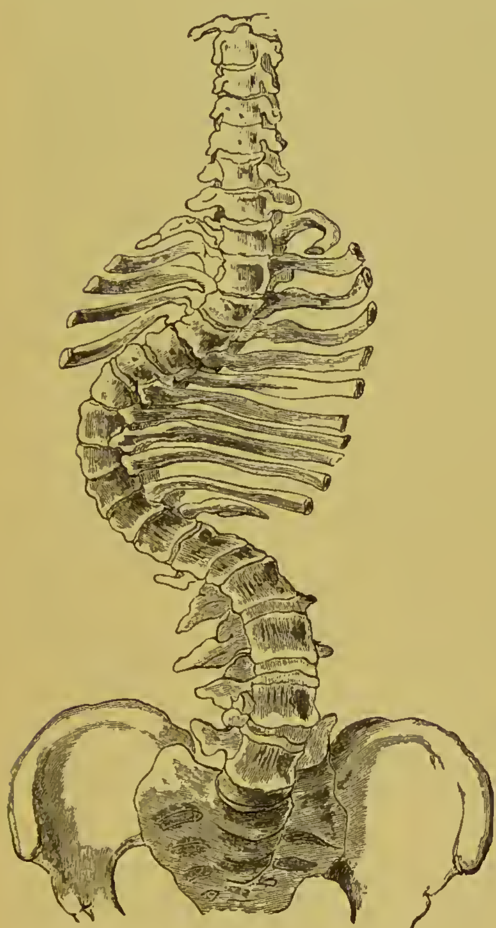


Fig. 383.—Right-sided dorsal scoliosis.

Fig. 384.—Extreme left-sided lumbodorsal scoliosis with marked rotation of the spine.

The prognosis of this early rhachitic scoliosis is altogether favourable if proper treatment is begun as soon as possible (see Principles of Surgery, § 108), and the children are made to lie upon a firm mattress. Such children should sit up as little as possible, and should not be carried about much. If necessary, they should wear supporting jackets and braces (see page 807 ff.). Here also, as in habit scoliosis, in the later periods of growth, massage and baths are very useful. In the most

common form of scoliosis also, from the age of thirteen to twenty (habit scoliosis), rhachitis plays an important part, much as in the development of genu valgum (Mikulicz, Kirmisson).

3. Under the designation pathological scoliosis we include all those cases which are conditioned upon diseases of the spinal column and the thorax. Scoliosis following inflammation (caries) of the vertebræ and the intervertebral disks is almost always associated with kyphosis, and the latter is the essential element of the deformity (kypho-scoliosis). In this category belong also the scoliosis following spondylitis deformans—e. g., of the lumbar segment of the vertebral column; that following cicatricial contractions of the muscles of the back—e. g., after burns and phlegmonous processes (cicatricial scoliosis); that following carious processes, with resulting defects on the ribs and the sternum; and also that following chronic empyemata, in connection with which the thorax, in consequence of cicatricial contraction, curves toward the sound side. In this class are also to be mentioned secondary scoliosis of the cervical segment of the spine in connection with torticollis resulting from unsymmetrical growth of the vertebræ; furthermore the scoliosis that follows paralysis (paralytic scoliosis)—e. g., unilateral paralysis of the muscles of the shoulder and the back; and finally scoliosis, especially of the lumbar spine, due to hysterical contractures of the muscles. Infantile paralysis sometimes leads not only to contractures on the extremities, but also to scoliotic contractures of the spinal column. In paralytic scoliosis we have to do in part with trophoneurotic disturbances in the bones of the vertebral column (Morvan).

All these forms of pathological scoliosis are usually mild, and often only temporary. If they continue, they become fixed comparatively late.

The treatment of pathological scoliosis is directed, above all, against its cause. In cicatricial scoliosis the cicatrices may be divided if necessary, and the defect covered by means of a pedunculated flap from the immediate neighbourhood. In suitable cases the application of permanent extension is to be advised, etc. Otherwise the scoliosis itself is treated by the same method which we shall give in detail for the treatment of habit scoliosis (page 802 ff.).

4. Traumatic scoliosis following badly united fractures of the vertebræ and unreduced dislocations or partial dislocations of the vertebral column is very rare. Fractures frequently give rise to a kyphotic curvature of the spine (see also Fractures and Dislocations of the Spine).

5. Static scoliosis arises from unequal length and other functional disturbances of the lower extremities. Its chief cause is obliquity of

the pelvis arising from the shortening of one leg—e. g., in connection with contractures of the hip or the knee joint, or in connection with primary deformity of the pelvis, etc. Temporary scoliosis is sometimes observed in connection with acute muscular rheumatism (lumbago), inasmuch as the patient involuntarily inclines his spine or his pelvis toward the sound side in order to relax the inflamed muscles. Sciatica may in the same way give rise to a scoliosis, which is usually slight, and is likewise temporary. Here also the patient seeks to relax the inflamed and swollen nerve sheath of the sciatic nerve by bending the vertebral column, thus giving the pelvis an oblique position. Scoliosis among young violin-players has a similar origin. The development of static scoliosis can be easily understood from Fig. 385. If the pelvis assumes an oblique position, if its transverse axis (*a b c*) is inclined to one side or the other, the lumbar segment of the spine must then bend toward the side of the pelvis that is lowest in order to preserve the equilibrium of the trunk. For the latter reason also the dorsal segment

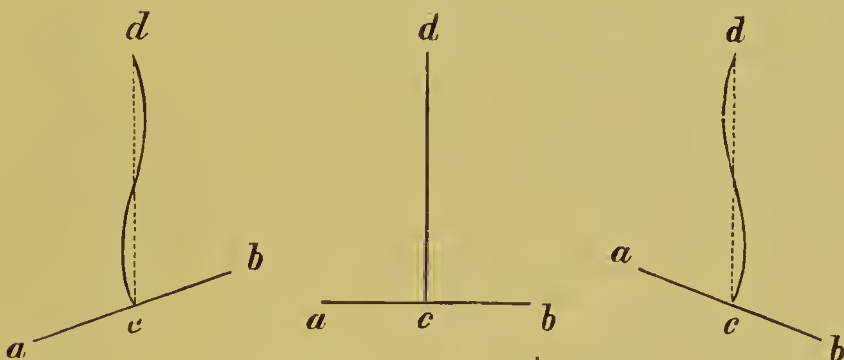


Fig. 385.—Mechanism of static scoliosis.

must incline laterally in the opposite direction, and the cervical segment, again, like the lumbar segment. Very marked scoliosis may arise in this way, which, however, usually becomes fixed only very late, in consequence of secondary deformity of the bones, especially when the scoliosis occurs after the growth of the bones is complete.

The prognosis of this static scoliosis is altogether favourable. It can be easily avoided and corrected by overcoming the obliquity of the pelvis—e. g., by giving the shoe worn upon the foot of the shortened limb a raised sole, or by remedying any contractures of the knee and hip that may exist, etc.

6. The most important and by far the most frequent form is habit scoliosis, which is to be regarded, briefly stated, as a deformity of the vertebral column due to the weight supported. It is observed especially among anæmic girls from eight to sixteen years of age who have

weak muscles, and who in many cases have had rickets in their earliest childhood. The development of this scoliosis is to be explained in much the same way as that of genu valgum (Mikulicz, Kirmisson).

The greatest variety of theories have been advanced regarding the mode of development of habit scoliosis. A muscular origin was for a long time regarded with favour, inasmuch as it was falsely supposed that it was a matter of primary muscular contracture. In consequence of this incorrect view, the muscles and tendons which were supposed to be primarily contracted were in many cases divided upon the concave side of the scoliosis, without, of course, remedying the difficulty. According to Stromeyer, the greater activity of the serratus magnus muscle on one side in the act of respiration is of significance in the development of right-sided dorsal scoliosis. Lesser emphasized the unequal action of the halves of the diaphragm, and sought, by dividing one of the phrenic nerves in animals, to bring about scoliotic curvatures of the spine experimentally. Hueter thought that he had found the origin of habit scoliosis in an unequal growth of the ribs, this causing an inequality in pressure. It need not be questioned in the least that scoliosis may arise from all these causes, but the chief element in habit scoliosis is of a quite different sort. Its real cause is the weight of the body.

As in static scoliosis, so also in habit scoliosis, it is very probably the obliquity of the pelvis which leads, in the first place, to a lateral deviation of the vertebral column from its perpendicular, longitudinal axis (see Fig. 385). This obliquity of the pelvis occurs because the children affected, especially when writing in school, do not sit properly. Our ordinary school benches are as badly constructed as possible. Permanent obliquity of the pelvis with corresponding curvature of the spine is often a result of special occupations, as, for example, among violin-players, among people who carry loads on one side, among smiths, tailors, shoemakers, etc. In all these employments the spine, in consequence of the obliquity of the pelvis, is bent to one side and rotated until checked by the contact of bone. If the view is correct that in habit scoliosis the obliquity of the pelvis is the principal thing, we have at the outset a primary scoliosis of the lumbar segment, as has been affirmed by a great number of authors. The scoliosis of the dorsal segment does not become distinct until later on. In consequence of the weight permanently supported by the vertebral column, an unsymmetrical growth of the bodies of the vertebræ and of the entire thorax then gradually ensues, and in this way the scoliosis becomes permanent and the spine becomes fixed in its abnormal posture. The development of the scoliosis is favoured by weak muscles, by lax ligaments, by present or past rhachitis, by chlorosis, anæmia, etc. Too tight lacing is especially injurious to the development of the youthful thorax by interfering with the growth of the bones and muscles.

The anatomical changes found in a case of scoliosis that has existed for a long time are the following: In consequence of the unequal distribution of the weight supported by the vertebræ which are inclined to one side and rotated on their perpendicular axis, their growth is unequal. The form of the scoliotic vertebræ is strikingly changed. They are bevelled off toward the concave side of the scoliosis—that is, they are wedge-shaped (Fig. 386), because here the growth of the bone is checked in consequence of the heavier

weight, while upon the unburdened convex side the growth goes on in an accelerated manner. This atrophy of the portion of the vertebræ on the concave side exists, according to Lorenz, not only in the bodies of the vertebræ, but also at the roots of the arches and on the articular processes. The vertebræ, however, are not only wedge-shaped in consequenee of the atrophy, caused by the increased pressure on the concave side, but they are also twisted as though turned about their vertical axis (Fig. 387). This torsion of the growing scoliotic vertebra is eonditioned mainly upon the unequal growth of the arch-epiphyses which has just been mentioned (Lorenz, Nicoladoni). In accordance with this, the bone fibrillation also of the scoliotic vertebræ is not vertical, as is normal, but oblique and curved (Volkmann, Lorenz). The torsion of the scoliotic vertebra affects its articular portion chiefly. The vertebra becomes turned because in consequence of its reduced power of resistance, resulting from rhachitis which usually exists, it yields to the continued abnormal pressure (Herth). A "torsion seoliosis" is gradually produced—that is, the vertebral column not only has a lateral deviation, but is also at the same time turned about its longitudinal axis. The vertebral foramen likewise undergoes changes naturally, in consequence of the unequal growth of the bone of the areh-epiphyses. Its circumference is smaller on the atrophic side—the side turned toward the concavity of the scoliosis (Fig. 387). The spinous processes of the vertebræ are sometimes bent toward the concave and sometimes also toward the convex side.

Fig. 386.—Two wedge-shaped scoliotic vertebræ.

Fig. 387.—Torsion of the vertebræ in scoliosis.

The scoliosis becomes more and more fixed in its abnormal posture in consequence of the deformity of the vertebræ which has been described, not through the ligaments and muscles; and if these changes in the form of the vertebræ exist, a complete cure of the scoliosis is no longer possible. All that can then be done is to keep the deformity from becoming worse. It follows from this that scoliosis must be combated with the greatest energy as early as possible.

Aside from the deformities of the vertebræ, there arise later changes of form also of the entire thorax and of the ribs. The form and position of the ribs are ehanged in a typical way. They are more sharply eurved or bent posteriorly upon the convex side of the scoliosis, so that there arises in this way the familiar posterior "hump" upon this side (Fig. 388 A). The ribs on the convex side are, moreover, farther separated from one another, while upon the concave side they are pressed together. On the concave side the thorax is sunken in laterally and posteriorly, whereas anteriorly, obliquely opposite the posterior hump of the convex side, lies the anterior "hump" of the concave side (Fig. 388 B). As is seen by Fig. 388, the scoliotie thorax is strikingly oblique. The intrathoraeic space on the eonvex side is diminished

in all its measurements, whereas upon the concave side it is increased in all of them except height, which is here also reduced. The sternum is pushed to the opposite side—e. g., to the left in case of right-sided dorsal scoliosis, as is likewise apparent from Fig. 388. The thoracic organs, lungs, heart, and large vessels are obliged to adapt themselves in position, to a greater or less degree, to this deformity of the thorax, and it is easy to understand that in extreme scoliosis functional disturbances of respiration and of the heart's action will result.

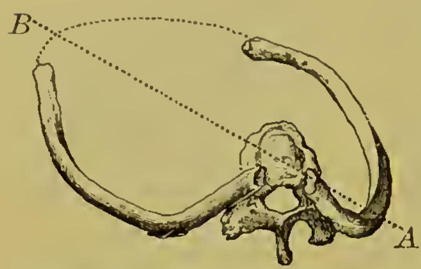


FIG. 388.—Obliquity of the thorax in right-sided scoliosis.

In case of long-continued marked scoliosis the pelvis is likewise oblique and unsymmetrical, in consequence mainly of the deformity of the sacrum. The obliquity of the pelvis is the reverse of that of the thorax, so that in dorsal scoliosis with the convexity on the right side, for example, the left diagonal diameter of the pelvis is lengthened. We have already stated that in every case of extreme scoliosis of the dorsal segment of the vertebral column the lumbar and cervical segments are inclined toward the opposite side, so as to restore the equilibrium of the trunk.

The ligaments and muscles of the vertebral column undergo secondary changes only. They are stretched upon the convex side and shortened or contracted upon the concave side. The muscles on both sides, in every case of severe, long-continued scoliosis, are correspondingly atrophic and undergo more or less fatty degeneration in consequence of inactivity, especially in cases of fixed scoliosis.

The symptomatology and course of scoliosis may be divided into three stages or degrees: 1. Oblique carriage without striking deformity. 2. Commencing torsion of the vertebræ and development of the posterior prominence of the ribs. 3. Fixation of the scoliosis.

Scoliosis develops very gradually. Let us take as an example a typical case of habit scoliosis in a young anæmic girl, from eight to twelve years of age, with weak muscles. The first symptom which strikes us in such children is, in case of dorsal scoliosis with the convexity on the right side, for example, the elevation of the right shoulder and the prominence of the right scapula. The left hip is also somewhat prominent and the left flank somewhat deepened. The obliquity of the hips shows itself very early in primary lumbar scoliosis. At first, one can easily correct the deformity by lifting the child up by the axillæ.

In the further course of the scoliosis the deformity of the vertebral column and the thorax becomes more and more marked. If we hold to the example of the most frequent form, the right dorsal scoliosis, the deviation of the spinous processes to the right begins to become more

and more apparent, and, above all, the posterior prominence of the ribs on the convex side begins to be more and more distinct. The left (concave) half of the thorax is plainly flattened or deepened behind and on the side, the sternum is pushed to the left, and the right scapula is elevated and more prominent. The compensating curvatures of the lumbar and cervical segments of the spine become more distinctly visible. In consequence of the left-sided lumbar curvature, the right flank is deepened and the right hip projects, while on the left (convex) side of the lumbar segment a corresponding fulness can be seen and felt. No scoliosis that is so far advanced that the anterior and posterior prominence of the ribs are plainly visible can be overcome by any treatment. If such children are suspended, the scoliosis is partially corrected, but the anterior and posterior prominences of the ribs and the displacement of the sternum persist to a greater or less degree.

The deformity usually increases very slowly, but sometimes in rapidly growing girls its course is comparatively very rapid, so that in a few months extreme curvatures develop if an energetic and suitable treatment is not promptly begun.

In the later stages, in consequence of the above-described increasing deformity of the vertebræ and the thorax, the scoliosis becomes fixed, or, in other words, stationary (see Figs. 382–384). This stationary period of the scoliosis may occur at any stage, so that one finds both mild and extreme degrees.

The thoracic organs sometimes, it is true, adapt themselves very strikingly to the deformity of the thorax without the appearance of special disturbances, but in extreme cases respiratory and circulatory difficulties are always present. According to Bouvier, heart disease and apoplexy are the most frequent causes of death among those affected with scoliosis. Pain may arise from pressure upon the nerve roots, and particularly upon the intercostal nerves of the concave half of the thorax. In consequence of contraction of the pelvis, parturition may be more or less interfered with in the case of scoliotic women.

The œsophagus, according to Hacker, never participates fully in the curvatures of the vertebral column. In the more marked degrees of scoliosis, however, the œsophagus may curve or bend more or less. Deglutition is not interfered with by this curving of the œsophagus, but the introduction of stiff œsophageal bougies may be impossible.

We have already sufficiently indicated the prognosis of scoliosis. The earlier proper treatment is begun, and the better the state of nutrition the more favourable is the prognosis. In the first stage of scoliosis a complete cure is possible so long as the deformity can be completely corrected by suspension. In the second stage, when the anterior and posterior prominences

of the ribs are already present, one must be satisfied to arrest the trouble by his treatment and prevent it from becoming worse. If the scoliosis has become fixed and is extreme, treatment is powerless and one can only prevent or retard its progress.

An early diagnosis is of the greatest importance. Unfortunately, patients often come under proper treatment too late. It is to be lamented that incipient scoliosis is made too little of by many physicians, and that parents and patients are frequently reassured by the statement that "the trouble will soon be outgrown." The diagnosis should be made in each case as carefully as possible, and one should secure for himself an exact idea of the degree of the scoliosis by inspection, palpation, and measurement, the clothing of the patient being sufficiently removed for the purpose. By lifting the patient by the axillæ, by suspension in Sayre's apparatus, and by pressure upon the convex side of the scoliosis, one should seek to determine whether and to what extent the deformity may be corrected. One should always note the position of the pelvis, and ascertain whether the length of the lower extremities is the same. The degree of the scoliosis is shown by the lateral deflection of the vertebral column, by the size of the posterior prominence of the ribs, and by the deformity of the thorax in general. The deviation of the spinous processes of the vertebræ is of less value. It is too often deceptive. For measuring the lateral deflection of the vertebral column in scoliosis, the pendulum rod, after Heineke, is very useful. A belt with a triangular metallic plate is buckled around the pelvis. The apex of the plate lies exactly above the rima ani. Attached to the metallic plate is an India-rubber cord, which is carried to the seventh cervical vertebra. Before the apparatus is placed in position the spinous processes are marked with a lead pencil. For measuring the deflection from the median line, a pendulum rod is used which is attached to a perpendicular rod going from the plate of the belt, is marked off into centimetres, and reaches to the head.

For more exact measurements, apparatus have been invented which are in part very complicated. I mention only Bühring's apparatus, the thoracograph of Schenk, the very useful scoliosometer of Mikulicz, and the measuring and drawing apparatus of Schulthess. These different forms of apparatus are described more in detail in the handbooks of general and special orthopædic surgery by A. Schreiber, Hoffa, and others, to which the reader is referred.

The simplest way of recording the deformity of the thorax is to encircle it with a pliable lead tape, and then make a drawing of the same upon paper. The same method may be used for determining the amount of lateral curvature.

Treatment of Scoliosis.—In the first place, prophylaxis, consisting in care for proper hygienic surroundings and good food, together with development of the muscles by massage, gymnastics, swimming, etc., is of the greatest importance. Children with weak muscles who are inclined to scoliosis should have proper benches at school, and it should be carefully seen to that they keep themselves straight when sitting, and that they do not sit too long. Children disposed to

scoliosis should also rest in a horizontal position upon a firm mattress an hour or more every day. Fahrner, Kunze and Erismann, Staffel, Lorenz, and others have suggested suitable school benches. The distance between the height of the seat and the top of the desk should vary with the height of the child—that is, the desk should be adjustable. This distance should be for boys about one eighth and for girls about one seventh of their height. The bench should have a support for the back with a backward slant. The question whether oblique or vertical writing is more favourable for the development or carriage of school children, from an ophthalmoscopic as well as from an orthopædic point of view, has been of late the subject of considerable discussion. According to the investigations of G. Burckhard, vertical writing is by far the more strongly to be recommended from an orthopædic standpoint. The best position of the body in vertical writing is secured when the copy-book lies approximately in front of the middle of the chest when the child writes, and parallel to the edge of the desk or the line of the pelvis. The so-called shoulder-braces by which the shoulders are drawn backward are of little use. They are injurious, in fact, in some ways, because the physiological kyphosis of the vertebral column is thereby interfered with, and its lateral inclination and rotation are favoured. The physiological kyphosis of the spine prevents to a certain degree the development of scoliosis (Sayre).

The treatment proper of scoliosis should be begun as early as possible. It consists in the adoption of orthopædic measures suited to the special case, and, above all, in a general strengthening regimen (good nourishment, gymnastics, swimming, brine baths, sea baths, etc.). As regards the latter, I attach much importance to giving food rich in lime in the form of legumes, Graham bread, limewater, and carbonate and phosphate of lime in powder form, as in rhachitis. The strengthening of all the muscles of the thorax—e. g., by massage as well as by various gymnastic exercises—is of the greatest importance (Landerer, Reynier, the author). The Swedish gymnastics are excellent with their resistance movements. The same is true of home gymnastics as devised by Schreiber. All those exercises are very beneficial which tend to change the existing scoliosis into a lateral curve in the opposite direction (so-called self-redressment). In case of dorsal scoliosis with the convexity on the right, one has the children bend to the right side as far as possible with the right arm set firmly akimbo and then take a deep breath while the left arm is carried up over the head (Schildbach). The effect is increased by pressure upon the convex side of the thorax. I apply by preference lateral suspension, which is also warmly recommended by Lorenz, Schreiber, and

others. I let the children lie in the daytime, the length of time varying according to the degree of the scoliosis, with their convex side over a roller cushion firmly stuffed with horsehair, so that the scoliosis is overcorrected. Lorenz has the patient lie over an adjustable roller cushion in a suspended posture. Lorenz's apparatus may be improvised by fastening a padded crosspiece between two door posts and securing a long sling to a ring screwed into the floor.

Of the different forms of gymnastic, fixation, and detorsion apparatus, I mention in addition the suspension apparatus and scoliosis

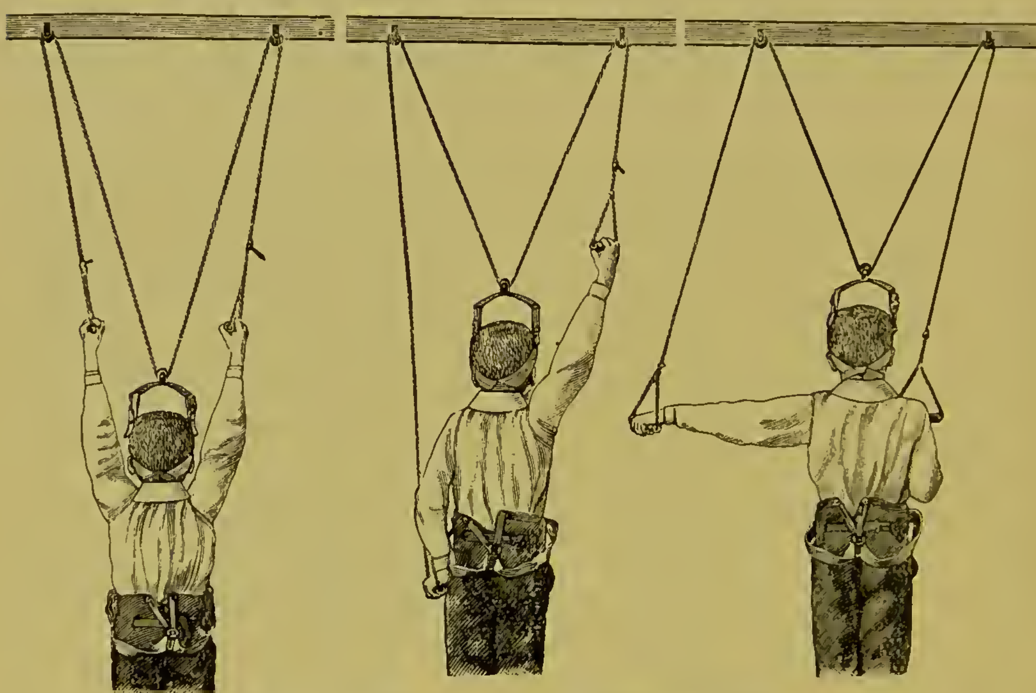


FIG. 389.—Orthopædic gymnastic apparatus for scoliosis.

bars of Beely, the detorsion apparatus after Hoffa and Schede, the apparatus of Lorenz, the very excellent apparatus of Wolfermann (Strasburg), etc. For suspension of the body and stretching the spine, the simple orthopædic gymnastic apparatus of C. Schmid is especially to be recommended (Fig. 389), which is very cheap and can be set up in any room.

Barwell's suspension sling or the suspension belt works in much the same way as the detorsion apparatus. This sling, which is about three inches wide, hangs over the bed and is fastened to the ceiling by means of a cord. The patient places himself in it in a lateral position, so that here also the scoliosis is overcorrected in the opposite direction. Rauchfuss's sling is simpler than Barwell's. In this also the patient is given a lateral position (see Fig. 406, page 819). Hammocks can

also be used to advantage as apparatus for correcting scoliosis. Bühring, Heather Bigg, Lorenz, Beely, Heusner, and others have recommended apparatus of this nature. The utility of such apparatus is limited. Extension beds and extension frames, after Beely, are still the most useful. Permanent weight extension by means of the Glisson collar and elevation of the head of the bed is strongly to be recommended. All apparatus for giving the patient a certain position should, judging from my own experience, be applied only by day, not at night. Children often turn in their sleep, so that the apparatus does more harm than good.

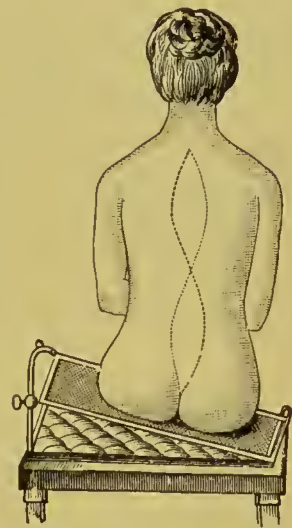


Fig. 390.—Volkmann's oblique seat for scoliosis.

In order to correct the scoliosis while the patient is seated, when at school, for example, Barwell and Volkmann have recommended an oblique seat (Fig. 390) which can be easily improvised by the use of a wedge-shaped hair cushion. A ladies' saddle has a similar effect in riding, a fact which Schreiber has properly called attention to, so that riding is to be recommended in suitable cases for scoliotic women.

Supporting apparatus play an important part in the treatment of scoliosis. They must be used only in a form which permits them to be easily removed, and must not be allowed to interfere with the activity of the muscles. A great variety of forms of supporting apparatus has been recommended, but many of them do not fulfil their object, which is to support the spine and to overcome the deformity. Attempts have been made to accomplish the correction of the deformity, particularly by elastic tension, by pressure with pads, by special splints, etc. Any apparatus which works by elastic tension—e. g., that of Barwell, E. Fischer, Hossard, and others—are very simple to be sure, but, judging from my own experience, they are insufficient. They correct the deformity in part, but do not support the spine sufficiently, and are not well borne permanently. As has been said, the apparatus of Wolfermann (Strasburg) is strongly to be recommended. Of the forms of supporting apparatus for correcting the scoliosis by means of a spring, that of Nyrop is best known. I have given up the use of this apparatus also. Its effect is insufficient and sometimes directly injurious. The shoulders are drawn very strongly backward, the amount of pressure is insufficient, and if it is made to act more strongly, as is sometimes necessary, it is not tolerated.

A good and simple supporting brace for scoliosis should consist, according to my view, of one or two steel rods with two shoulder supports and a pelvic belt. The steel rods should be so arranged that they can be lengthened. The correction, particularly of the posterior prominence, by a broad pad is sometimes necessary. Of late years I have used exclusively in scoliosis the supporting apparatus represented in Fig. 391, which Volkmann also used in many cases. If necessary, I have a broad, adjustable, padded metallic plate fastened on for correction of the posterior prominence. I am thoroughly satisfied with this apparatus.

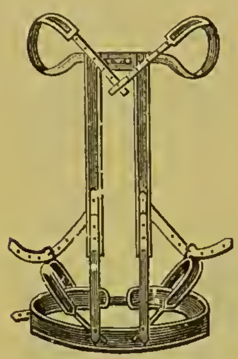


Fig. 391.—Supporting brace for scoliosis.

The very excellent Goldschmidt-Eulenburg apparatus, with a broad steel rod, spring shoulder crutches, and adjustable pad, is also widely used.

Jackets can not be dispensed with in the treatment of scoliosis—e. g., those of plaster of Paris, after Sayre, or of felt, leather, cellulose, paper, water glass, or some pliable material with splints of metal or wood inserted. Sayre has performed an extremely meritorious service in the treatment of scoliosis by the introduction of plaster jackets. Among German surgeons, Sonnenburg in particular has advocated the use of the plaster jacket. He applied it in two hundred and five cases of spinal affection, one hundred and eighty-three of them being scoliosis and twenty-two kyphosis. In milder cases of scoliosis jackets of some pliable material, well supported at the waist with steel rods, and if necessary with arm supports, are sufficient. Many surgeons use jackets of plaster of Paris or felt exclusively, rejecting all other supporting apparatus. I do not consider this wise. Jackets of plaster and felt have their disadvantages also, especially in warm weather. They have likewise an injurious effect upon the muscles of the thorax, which easily become atrophic. To avoid this atrophy of the muscles, massage must always be resorted to systematically. Another disadvantage of all jackets of a hardening material consists in the fact that they have to be frequently renewed. Jackets of felt and plaster of Paris are especially adapted for scoliosis of the second degree and for severe cases of the third degree accompanied by pain and disturbances of the thoracic organs. Generally speaking, however, the stiff jackets of plaster and felt are not so frequently applied at present on account of the atrophy of the muscles that they occasion. Soft jackets of some yielding material made over plaster moulds and provided with iron supports, after Beely, for example, are better (see Figs. 399 and 400, page 811). In the use of these, respiration and the action of the muscles of the

thorax are by no means so interfered with as with the stiff plaster and felt jackets.

The plaster-of-Paris jackets are made as follows: The patient must remove all clothing as far down as the pelvis. Sayre suspends his patients in a special apparatus represented in Fig. 392. A simpler way is to fasten the suspension apparatus represented in Fig. 393 to a ring in the ceiling of the operating room, and to suspend the patient by means of the well-padded headgear, K, laid about the nape of the neck and the lower jaw, and the shoulder straps A. The patient is raised by pulling upon the cord S, and he must be suspended so that the toes still touch the floor (Fig. 395). Special care must be taken to protect the ears and the region of the lower jaw from pressure, by means of thick layers of padding. Of late I use the headgear and the shoulder straps only in severer cases. I usually suspend the patient without them by having him seize with both hands the iron crossbeam to which (in Fig. 393)

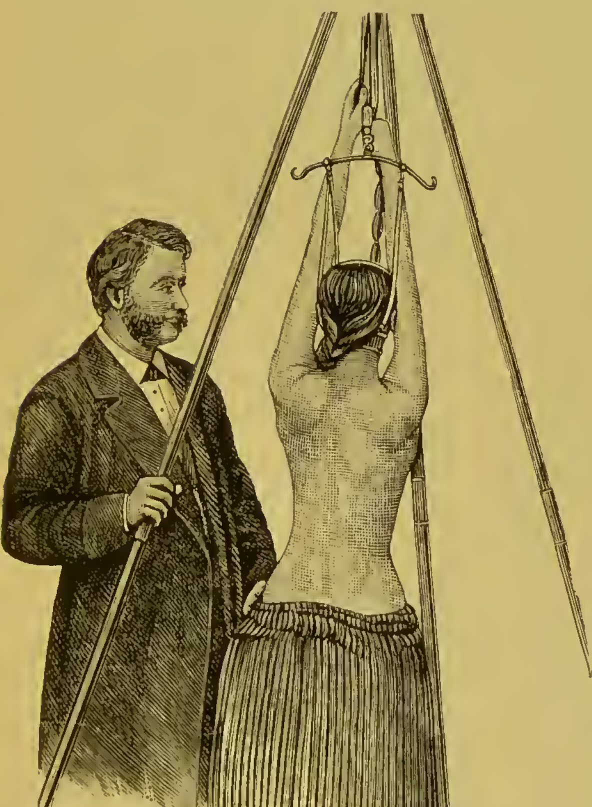


Fig. 392.—Sayer's suspension apparatus for use in putting on plaster jackets.

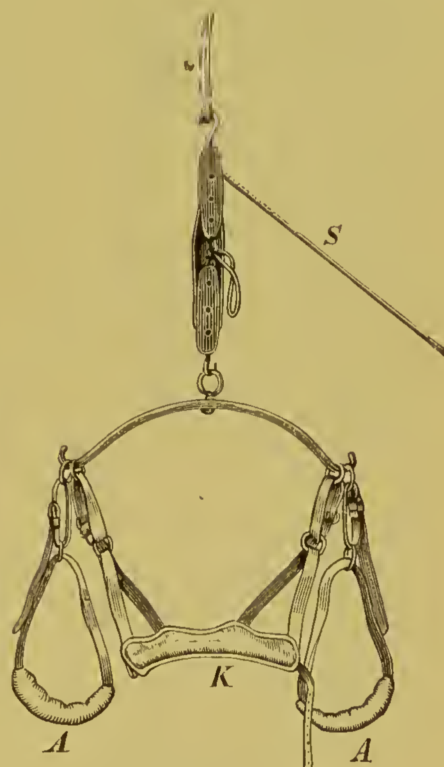


Fig. 393.—Suspension apparatus for use in putting on plaster jackets: *A*, straps for the arms; *K*, head gear; *S*, rope for suspending the patient.

the suspension apparatus is fastened, or I proceed according to Fig. 395, but without the headgear. The method of suspension used by Beely (Fig. 394, *a* and *b*) is very efficient, as is also that used by Lorenz (Fig. 395). In both methods the pelvis is firmly fixed, so that the patient can not move to and fro during the application of the plaster-of-Paris jacket.

After the patient has been suspended, the plaster-of-Paris dressing is applied

over a snugly fitting woollen shirt, while the scoliosis is in its corrected state. The best way is to cut out a piece of the material long enough to reach to the popliteal spaces, and fasten it together in the median line in front, at first with safety pins, and then have it sewed together from the neck down to the pelvis. A long pad of cotton is pushed under the shirt, corresponding to the middle line of the thorax, from the neck to a point below the navel, which is to be made thicker in the region of the stomach in order that the jacket may not press here. The shirt is fastened over the shoulders by means of bands. The axillæ are properly cut out. It is often a good plan to leave a space about the projecting scapula by laying on plates of felt, which are removed after the hardening of the plaster-of-Paris dressing. They may also be allowed to remain by sewing them to the shirt. In this way one may exer-

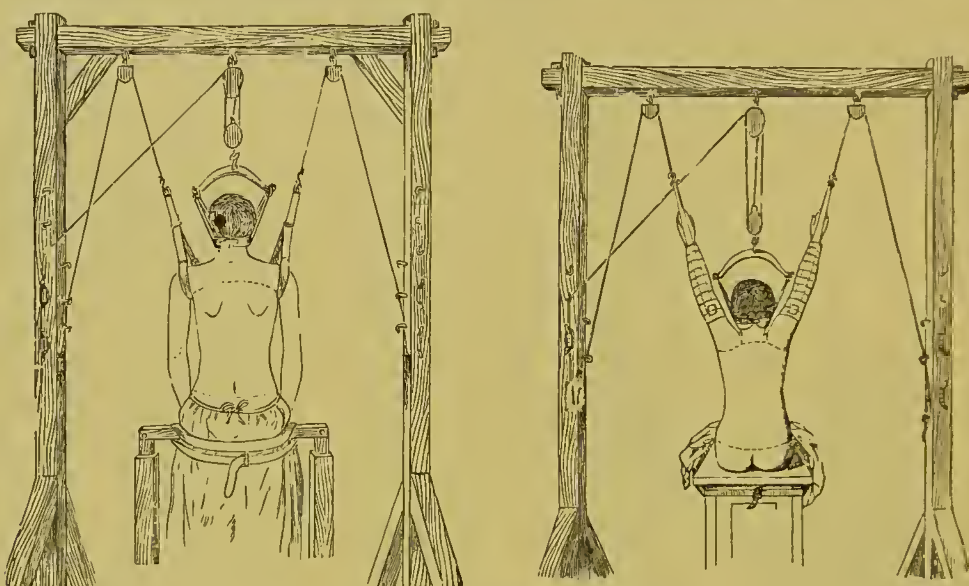


Fig. 394.—Beely's method of suspension.

cise pressure upon the posterior prominence. In treating women one must, of course, protect the breasts from pressure by leaving sufficient space.

During the application of the bandages an assistant must constantly smooth them out with the hands in order that the plaster of Paris may be properly pressed into the shirt and harden more quickly. In a typical dorsal scoliosis the plaster-of-Paris jacket should extend from the axillæ beyond the crest of the pelvis, so that the upper part of the pelvis and the sacrum are included in the dressing. Only the best sculptor's plaster of Paris should be used. The bandages must be well soaked, and then moderately squeezed out. If necessary, one can insert shoemaker's thin board or metallic splints for support, or felt, pieces of sponge, etc., for padding the inside. The jackets must not be made too thick or too heavy. Six to eight bandages of medium width are usually sufficient for a patient twelve years of age. Plaster of Paris is not spread on with the hands at the end. If, some minutes after the last plaster-of-Paris bandage has been applied, the jacket is moderately stiff, it is cut down in the median line, corresponding to the strip of cotton placed beneath, with a plaster knife. It is then taken off by carefully lifting it

from the patient to the right or to the left. The latter is then liberated from his suspended posture. After removal of the jacket, it is fixed in its correct shape by means of gauze bandages, and the antero-posterior diameter, which has been enlarged in consequence of placing the cotton beneath, is somewhat shortened by drawing the jacket slightly apart transversely. The waist is also modelled more exactly by deepening the depression indicated in the jacket. The latter is best dried upon the stove. On the next day, when it is dry, it is suitably cut out, especially above in the axilla and below in the region of the pelvis, in order that it may not cause pressure in the axilla and at its lower edge when the patient is sitting. The edges of the shirt are turned up over the outer surface of the jacket, and the latter is bound with leather and provided with lacing arrangements. It is then ready for wear (Fig. 396).

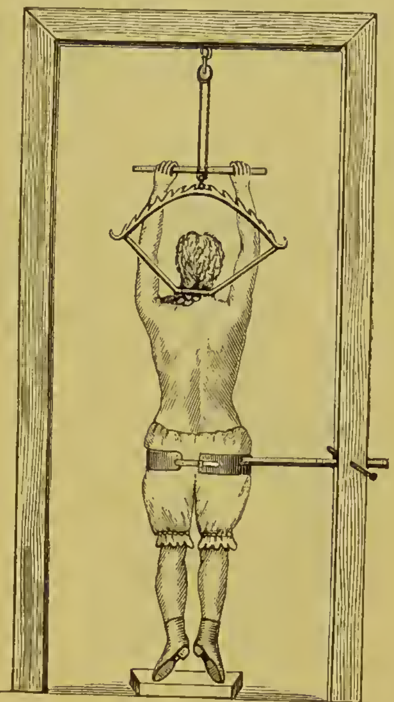


Fig. 395.—Lorenz's suspension apparatus.

In order to preserve an overcorrection of the scoliosis after the jacket has been applied, Lorenz has recommended a lateral-traction jacket (Fig. 397), a pressure jacket for dorsal scoliosis, and a girdle jacket for lumbar scoliosis (Fig. 398, *a* and *b*). These jackets should only be worn at home, and the patient is thereby compelled to bend the spinal column in a direction opposite to that of the existing scoliosis. The lateral-traction jacket (Fig. 397) fixes the upper part of the body in case of right-sided dorsal scoliosis to the pelvis so that the part below bends to the left. It reaches on the right side only to the tip of the scapula, on the left somewhat lower. The dressing is applied while the patient is standing, the upper part of the body is bent to one side by a band laid about the thorax, and the pelvis is held securely by a padded support (see Fig. 395). A plate of metal provided with holes is inclosed in the turns of plaster bandage passing around the pelvis and supplied with a ring. A strap from a laced gaiter on the thigh is fastened to the ring (Fig. 397, *a*) to prevent the jacket from slipping up at this place. The plaster-of-Paris jacket is of course arranged so as to be taken off.

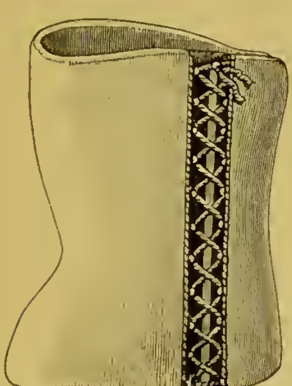


Fig. 396.—Plaster jacket for scoliosis.

The girdle jacket is applied in a similar manner in primary lumbar scoliosis, with an overcorrection of the scoliosis, while the patient is standing. In case of lumbar scoliosis, for instance, with the convexity on the left, the sole of the left foot is raised from two to three and a half centimetres, the pelvis is firmly fixed, and the trunk is inclined to the left and supported by a crutch. The plaster-of-Paris dressing is then applied

in this posture, and the lumbar segment of the spine—in left-sided scoliosis, for instance—is fixed in a curve which has its convexity to the right (Fig. 398, *a* and *b*).

The pressure jacket of Lorenz is so arranged that by means of plates of felt laid on the inner side of the jacket the thorax is compressed in a diagonal

Fig. 397.—Lateral traction jacket after Lorenz.

Fig. 398.—Girdle jacket after Lorenz.

direction. To make this possible, the flat, depressed parts of the thorax on the concave side are covered during the application of the jacket with thick plates of felt. These are removed after the jacket is prepared; the depressed parts of the thorax then have a corresponding space about them, and by pressure of the plates of felt, which are now to be placed on the inner surface of the jacket on the convex side, the thorax can be pressed toward the concave side of the scoliosis.

One may also apply the jackets with the patient lying across a hammock or lying on his side. Peterson places the patient on his side with the legs and the head supported upon separate tables. The intervening trunk is fastened in an overcorrected position to a crossbar by means of a strap or a folded three-cornered cloth, and raised by a pulley so that the scoliosis is fixed in plaster while in an overcorrected position. The strap or the cloth is included in the plaster-of-Paris jacket.

Bois recommends that the plaster-of-Paris jacket be made very thin, with strips of tin laid between. After sufficient hardening, the jacket is removed and two or three layers of a tarlatan bandage are applied on the inside and outside, which are saturated with a hot, well-purified ten-per-cent solution of glue. The same solution is then applied over this with a brush.

Corsets have been prepared from various other materials in place of plaster of Paris. Wooden jackets, for instance, are very useful—that is, those made of very thin splints of wood fitted to one another. The wooden jackets of Waltuch, made over a plaster-of-Paris model, consist of belts of wood or

thin shavings which are joined to one another by means of cabinet-maker's glue (Wiener klinische Wochenschrift, 1888, No. 10). Brunelli recommends a good glue mixture which when permeated with sweat does not smell badly: 100 grammes of cabinet-maker's glue is softened in water and boiled with 50 grammes of turpentine, 100 grammes of starch paste are added, and the whole thickened by placing it on the water bath. The wooden jacket is covered on the inside and outside with shellac to render it impermeable to dampness.

Harkes and Phelps praise the durability and lightness of paper jackets, prepared over a plaster-of-Paris cast from paper or a material made from pure hemp fibre in combination with a cement or glue substance. The jacket is cut open on both sides in the axillary lines, and the halves are held together by elastic lacings, so that respiration is not interfered with.

Hübscher prepares jackets of cellulose covered with glue. Pieces of cellulose corresponding to the back, front of chest, and sides are cut into shape, and are made so much too large that when placed upon one another the borders overlap each other about one centimetre. The cellulose is then placed in lukewarm water, not too long, and the plates are laid upon a plaster-of-Paris model and fastened there by means of a figure-of-eight gauze bandage. After drying, the bandage is removed and the plates of cellulose, which are now shaped to answer to the thorax, are covered on both sides with thin liquid glue (Cologne glue warmed in the bath). The edges of the plates are then glued to one another upon the plaster-of-Paris model. At the

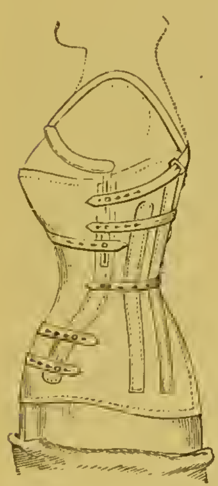
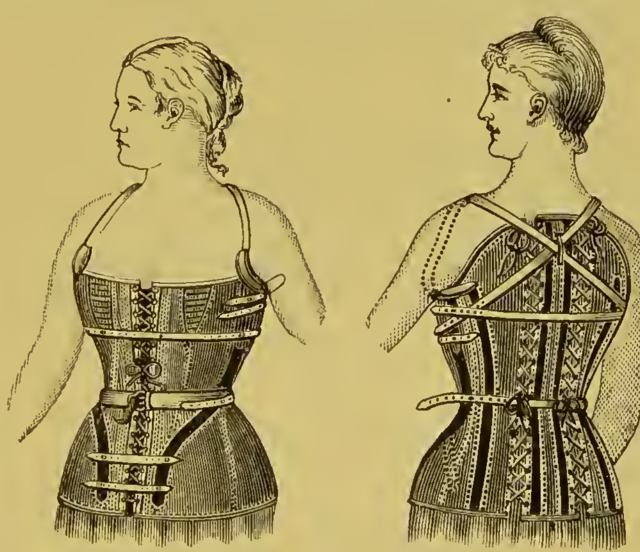


Fig. 399.—Beely's scoliosis jacket (side view).



a b

Fig. 400.—Beely's scoliosis jacket: *a*, seen from in front; *b*, from behind.

same time or, better, after the drying, a second thinner layer of cellulose is glued on. The dressing is then cut open in front, after becoming perfectly dry, and provided with hooks, lacings, etc. Cellulose prepared in this way is also adapted for other dressings, splints, protheses, etc.

The jackets of water glass are very practical. They are lighter and more durable. The first water-glass bandage that is applied over the woollen shirt

must be well squeezed out, as otherwise excoriations of the skin and eczema are easily caused. One may also use as the first bandage one of plaster of Paris. Karewski, at Israel's instance, recommended jackets of wirework and water glass. Leather jackets are often used.

Plastic felt also has been fitted to the thorax while the patient was suspended, or made into a jacket over a plaster-of-Paris cast or a plaster-of-Paris jacket.

Felt jackets are usually prepared in the following manner: The patient is suspended as described above and carefully enveloped in a wet flannel bandage covering the whole of the upper part of the body as a protection against the heat of the warmed plastic felt. The jacket of plastic felt, which has been warmed for about fifteen minutes in a sheet-iron stove heated at 212° F. and thereby softened, is moulded with the hands as quickly as possible to the thorax of the patient. The jacket is then taken off, and the patient is freed from his suspended position. Any pressing edges are cut away with the knife, folds are smoothed out with a hot iron, etc. The felt jackets are also provided with bands and buckles, and worn over a closely fitting shirt. One can also, as has been said, prepare the felt jackets over plaster-of-Paris models that are made beforehand (see also page 806) to fit the patient. P. Bruns recommended applying felt in a soft condition, cutting it, and then saturating it or covering it with a solution of alcohol and shellac (600 grammes of shellac to one litre of alcohol). Such jackets dry in four or five days in winter, and in two or three days in summer. Very excellent and ingenious jackets are prepared by Beely in Berlin (Figs. 399, 400).

For other modifications of jackets the reader is referred to pages 821 and 822 (Kyphosis).

§ 146. **Kyphosis.**—By kyphosis of the spinal column (from κῦφος, a bending, a protuberance, a hump) is understood a flexion curvature of the vertebral column whose convexity is directed backward. Etiologically and clinically two principal forms of kyphosis may be distinguished: 1. Growth kyphosis or habit kyphosis, in consequence of a stooping carriage, especially among young persons who are rhachitic or have weak muscles and ligaments. 2. Kyphosis due to tubercular inflammation of the vertebræ (tubercular spondylitis), and after vertebral defects arising from other pathological processes—from tumours, for instance, or gummata. We have already mentioned traumatic kyphosis when treating of fractures and dislocations. We shall here occupy ourselves only with habit kyphosis and with kyphotic curvature resulting from tubercular disease of the vertebral column.

Habit kyphosis is observed especially among rhachitic children in their second or third year, and also in the later growth period of children, in consequence of a stooping or humped posture in reading and writing. It is particularly common among anæmic girls with weak muscles, from ten to sixteen years of age. It is feared by anxious parents, though mistakenly so, to be incipient scoliosis. Such children,

who hold themselves crooked—that is, bend the back moderately—do not usually become scoliotic, as we have already said. Exceptions, however, occur.

Finally, this deformity appears also at a later age among persons whose employment necessitates their stooping over continuously—e. g., hod carriers, cobblers, etc. This kyphosis in later life caused by one's employment is conditioned largely, no doubt, upon an atrophy of the vertebræ and the intervertebral disks from pressure, favoured by the age of the patient. A corresponding atrophy of the muscles goes hand in hand with this senile atrophy of the bones and the ligamentous apparatus, so that the patient loses more and more the power to hold himself erect.

In very rare cases the kyphosis is conditioned upon osteomalacia.

Especially the rhachitic kyphosis in very early childhood may be extreme, but it usually disappears with the cure of the rickets. It is characteristic of all these forms of kyphosis due to supporting the weight of the body that the spine is not so distinctly bent as in tubercular spondylitis, but forms more of a curve in which the whole dorsal segment of the spine takes part.

The treatment of habit kyphosis is directed, above all, against its cause. In case of rickets this is to be properly treated (see Principles of Surgery, § 108). Such children must lie upon a firm mattress, in a dorsal position continuously, with a Rauchfuss's sling (see Fig. 406, page 819), or a roller cushion stuffed with hair beneath them. A supporting apparatus may be necessary. Schreiber recommends, for instance, a gutta-percha splint formed to the back, which is fastened by two shoulder bands and a broad body band.

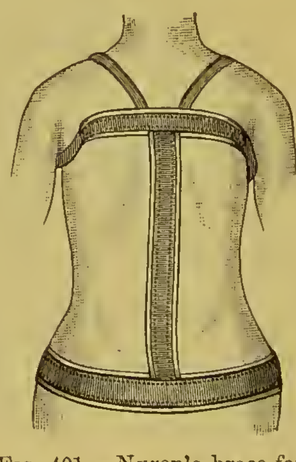


Fig. 401.—Nyrop's brace for round shoulders (habit kyphosis).

In the case of children from the age of ten to sixteen years whose kyphosis is due to a vicious posture, especially when sitting, one must, above all, compel the children to hold themselves straight. A brace will be used if necessary. There are a great number of braces, but they are in part useless. A thoroughly good brace should consist, like the supporting apparatus for scoliosis, of a pelvic band, a posterior splint of steel, and shoulder braces. The braces which work by elastic traction are either not tolerated for any length of time or are insufficient. Nyrop, Heather Bigg, Staffel, and others have suggested very good braces. Fig. 401 represents the serviceable spring brace of

Nyrop, which consists of a pelvic band, a backward springing support for the back with a transverse bar, shoulder crutches, and shoulder braces. The chest is not in the least constricted by this brace.

Fig. 402.—Tubercular kyphosis in a boy of twelve.

The treatment of kyphosis which appears in later life in consequence of the patient's occupation is, generally speaking, attended with little success, and, as matters are, can not usually be carried out, inasmuch as the patient must attend to his work. The discomfort is also usually slight.

The treatment of kyphosis resulting from osteomalacia is directed chiefly against the latter (see Principles of Surgery, § 109).

For the treatment of traumatic kyphosis the reader is referred to §§ 140, 141 (Fractures and Dislocations of the Spine). If supporting apparatus or jackets are necessary in connection with traumatic kyphosis, or kyphosis resulting from osteomalacia, tumours (carcinoma, sarcoma), or gummata, they are prepared in the same way, generally speaking, that will be described more in detail for tubercular kyphosis.

Kyphosis following Tubercular Spondylitis (Pott's Disease).—In pronounced cases of kyphosis resulting from tubercular disease of the bodies of the vertebræ and the intervertebral disks, with carious destruction of the bone, there is a projection or angular deformity of the spine (Fig. 402). There is an enhanced flexion of the vertebral column, and the hump or gibbosity at the diseased part of the spine projects more or less sharply. Tubercular spondylitis was first described in detail in 1783 by the English surgeon Pott, for which reason it is called Pott's disease or Pott's curvature. The disease, however, was well known in earlier times. The deformity is most frequently observed in children from three to ten years of age. Beyond the fifteenth year the disease is more rare. Among two hundred and twenty-eight cases, Nebel counted only twenty-eight children more than fifteen years old. Boys are more subject to the disease than girls.

The anatomical changes attending tubercular spondylitis or tubercular kyphosis are as follows: The disease begins most frequently as a tubercular osteomyelitis or periostitis of the body of the vertebra, less often in the intervertebral disks, in the articulations or in the vertebral processes. At the beginning of tubercular spondylitis pain is often felt in the cutaneous branches of the involved spinal nerves—e. g., the cervical plexus; also pain in the region of the disease from pressure or movement. In the further course rigidity of the vertebral column and swelling and infiltration of the diseased part become more and more striking. The tubercular ostitis of the body of the vertebra leads in its further course to a carious destruction, to a defect, and hence the spine sinks in at this point. The extent of the tubercular spondylitis is very variable, and its course is usually chronic. The greater part of the body of a vertebra is sometimes destroyed with comparative rapidity by caries, or an encapsulated caseous focus with a sequestrum may exist for years in the body of a vertebra without the occurrence of kyphosis. In other cases the tubercular process breaks through the body of the vertebra after a short time, attacks the intervertebral disk, and passes over to the next vertebra. Extensive destruction can come about in this way, and an entire vertebra may completely disappear. In Fig. 403 the fifth and sixth dorsal vertebræ have been almost completely destroyed as well as the greater part of the seventh, eighth, and ninth. As in the long, hollow bones, so here also epiphyseal separation sometimes occurs. The greater the destruction of the bone, the more pronounced is the kyphotic curvature of the spinal column, the hump. The progressive deformity is, however, not infrequently checked by the formation of new bone or osteophytes about the tubercular focus or from one vertebra to another. Compensatory curvatures in the opposite direction, corresponding to the bending of the vertebral column at the site of the disease, then develop—e. g., in case of gibbosity of the dorsal segment of the spine, a lordosis of the cervical and lumbar segments.

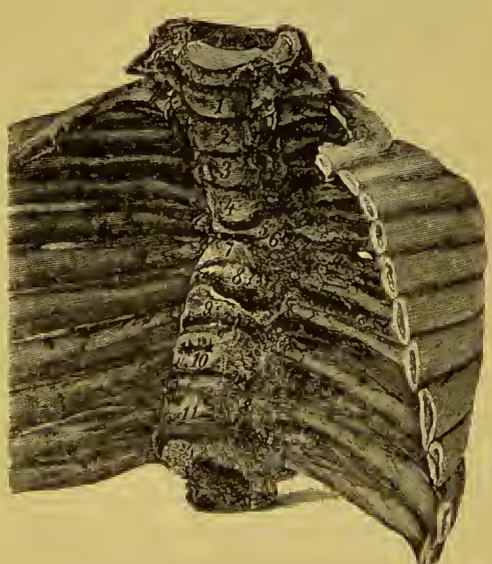


Fig. 403.—Extensive tubercular spondylitis of the fourth to the ninth dorsal vertebræ. (Pathological collection at Leipsic.)

Of the other anatomical changes attending tubercular spondylitis, the so-called spinal or gravitation abscesses are especially important. There are sometimes large collections of pus, which, in consequence of gravity and the anatomical relations, sink correspondingly downward. The direction taken by these abscesses, as Henke, König, Soltmann, and others have shown, depends upon the arrangement of the interstices, the fasciæ, and aponeuroses. The abscesses from the upper cervical vertebræ appear as retropharyngeal abscesses. They cause a swelling beneath the mucous membrane of the pharynx, and produce, according to their size, dyspnœa and dysphagia. Suf-

focation in consequence of aspiration of pus into the air passages may result from sudden rupture of the abscess or careless opening of the same by incision (see also page 548). The spinal abscesses of the cervical segment of the spine sometimes point externally in the lateral region of the neck—e. g., in front of the trapezius or in the supraclavicular fossa. Abscesses from the cervical vertebræ and the upper dorsal vertebræ descend more rarely in the direction of the axilla or make their way along the ribs and appear beneath the skin of the back or the front of the chest. The pleural cavity is invaded only in exceptional cases.

The spinal abscesses originating in the dorsal vertebræ most frequently make their way downward along the aorta as far as the peritoneal cavity. They then follow the psoas muscle, and, passing under Poupart's ligament and through the femoral ring, reach the thigh. The psoas muscle may be more or less involved in the suppuration ("secondary tubercular psoitis"). These tubercular abscesses which spread along the psoas muscle lead comparatively early to a contracture of the thigh, and they are not infrequently confounded with coxitis. The psoas abscesses, besides pointing on the thigh, may do so in the inguinal region above Poupart's ligament or in the scrotum, or they may gain access to the true pelvis and leave it through the greater sciatic notch. Cases of the latter class are also very easily confounded with coxitis. We have already mentioned that the abscesses sometimes spread along the ribs and appear beneath the skin of the back and the front of the chest; also that they rarely break through into the pleural cavity. In the peritoneal cavity the abscess may rupture into the intestine, bladder, or rectum. Tubercular fistulæ of the rectum are now and then caused by such tubercular spinal abscesses after caries of the vertebral column. The vessels also—e. g., the vertebral artery and the aorta—may be eroded by the suppuration.

FIG. 404.—Extreme kyphosis due to tubercular destruction of the dorsal vertebræ but without compression of the cord; no paralysis.

Finally, the behaviour of the spinal cord and the nerve roots that pass through the intervertebral foramina is important. In spite of very decided angular deformities, the spinal cord often adapts itself fully to the diminished room without the occurrence of any disturbance (Fig. 404), especially if the kyphosis increases slowly. If, on the contrary, an angular deformity develops rapidly, compression of the spinal cord is to be feared. In such cases compression myelitis may result with softening and fibrous changes in the spinal cord (G. R. Elliot), with progressive ascending and descending degeneration, which shows itself microscopically to be essentially a fatty degeneration of the nerve elements with growth of the interstitial connective tissue. The spinal cord may also be compressed by an abscess or thickened meninges. Finally, the spinal cord and its meninges may themselves be attacked by progressive tubercular disease, abscesses may break through into the vertebral canal, etc. All the above-mentioned results are possible according to the degree and the location of the disease, and their consequences are complete or incomplete paralyses which hasten the death of the patient—e. g., from bedsores, cys-

titis, etc. The reflex excitability is usually very noticeably increased. Upon striking the quadriceps tendon the leg flies upward with unusual force.

The secondary changes in the thorax and the pelvis should also be mentioned. The ribs become more or less approximated according to the degree of the kyphosis (Fig. 405). Pigeon-breast sometimes exists. The greater the diminution in space, the more likely are functional disturbances on the part of the lungs and the heart to ensue. Lannelongue found the aorta always adhering to the anterior surface of the bodies of the diseased vertebræ or to the wall of the abscess cavity and more or less bent. Circulatory disturbances may be due to this condition also.

Fig. 405.—Kyphotic thorax from tubercular spondylitis (Fig. 403 seen from behind).

The so-called kyphotic pelvis, which has a short transverse diameter, occurs, according to Zweifel, only in cases of kyphosis affecting the lumbar and sacral vertebræ. In consequence of such a kyphosis, the promontory is pressed backward and downward, and the sacrum acts as a direct wedge owing to the changed direction of the weight of the body. It presses the ossa innominata apart, above, whereas in the pelvic outlet it forces them together. The outlet is therefore diminished in its transverse diameter.

The symptomatology of tubercular spondylitis is clear from what has been said above. The most important symptoms are the formation of the posterior hump, the spinal abscesses, and possible disturbances on the part of the spinal cord and its nerves. The disease usually begins very gradually. The first symptoms noticed may be that the patient becomes easily tired in consequence of burdening the vertebral column by sitting for a considerable length of time. There may be pain also, especially in connection with movements of the spine, which are anxiously avoided. In the further course the vertebral column—e. g., the cervical segment—becomes more immovable and rigid, and when pressure is made on the spinous processes the patient complains of pain. One usually observes, moreover, at this time œdema and swelling in the vicinity of the diseased vertebræ. In consequence of the increasing destruction of the bodies of the vertebræ the spinal column sinks in more and more, and a varying degree of kyphosis ensues. The spinal abscesses then appear, the deformity of the vertebral column and the thorax becomes more and more striking, and there may finally ensue functional disturbances on the part

of the spinal cord, as above described. The course is sometimes very acute, so that death occurs before any deformity of the vertebral column is demonstrable. A cure is possible in every stage of the disease, even when large abscesses already exist. If recovery follows, it may be either with or without a permanent kyphosis. Subsequent recurrence or miliary tuberculosis are always to be feared. Death follows from progress of the disease, from its encroachment upon the spinal cord, from compression myelitis and its results, from miliary tuberculosis, from amyloid degeneration of the internal organs, from rupture of an abscess into the intestines or into the large blood-vessels, from bedsores in consequence of paralysis, etc. The prognosis of tubercular spondylitis is evident from what has been said. It is distinctly bad.

The diagnosis of tubercular spondylitis in cases that are already developed, with kyphosis and spinal abscesses, is easy. At the beginning of the trouble, however, it is often difficult or impossible. Children in whose case a suspicion of tubercular spondylitis is entertained should be stripped and carefully examined. The way in which such children stoop to pick up anything is characteristic. They keep the vertebral column perfectly straight, incline it forward a little, moving it only as a whole, and support themselves with the hands upon both thighs.

For the further course of kyphosis it is important to determine by measurement whether the hump increases or diminishes. Complicated measuring apparatus have been recommended for use here also, as for scoliosis. The simplest method, and one that is usually sufficient, is to apply a lead strip along the vertebral column and then to draw upon paper the outline which is thus obtained.

As was mentioned above, the contractures of the thigh in consequence of psoitis or of psoas abscesses pointing in the direction of the anterior or posterior region of the thigh may be confounded with coxitis. In case of contractures resulting from coxitis flexion is usually combined with abduction or adduction and rotation of the thigh, whereas in psoas abscesses there is usually flexion alone. By careful examination, with the patient under an anæsthetic, one can usually make the correct diagnosis.

Syphilis also, in its later stages, leads in rare cases to kyphosis of the vertebral column from gummatous osteomyelitis and periostitis of the bodies of the vertebræ and the vertebral arches, in the form, usually, of circumscribed gummata. Leyden, Volkmann, König, Jasinski, and others have reported such cases. Paralysis of the spinal cord from compression sometimes arises in this way. Syphilitic disease of the vertebræ is not infrequently accompanied with great pain.

The treatment of tubercular spondylitis should be in part of a suitable general nature and in part of a local character. As in every case of tuberculosis, so here also an effort should be made to strengthen the constitution of the child by good food and suitable hygienic surroundings. Brine baths, salt baths (up to three per cent), sea baths, and residence in a southern climate or an elevated health resort are strongly to be recommended. Of watering places, those where the springs contain iodine and bromine have a good reputation. Kreutznach, Nauheim, Oeynhausen, Reichenhall, Heilbronn (Adelheidsquelle), and other places are especially well spoken of. Cod-liver oil with phosphorus, or creosote, or preparations of lime, are given internally from time to time.

Local treatment consists at first in the use of ice and, above all, in relieving the diseased portion of the spine from pressure, especially by weight extension, by the use of Glisson's apparatus (see Fig. 377).

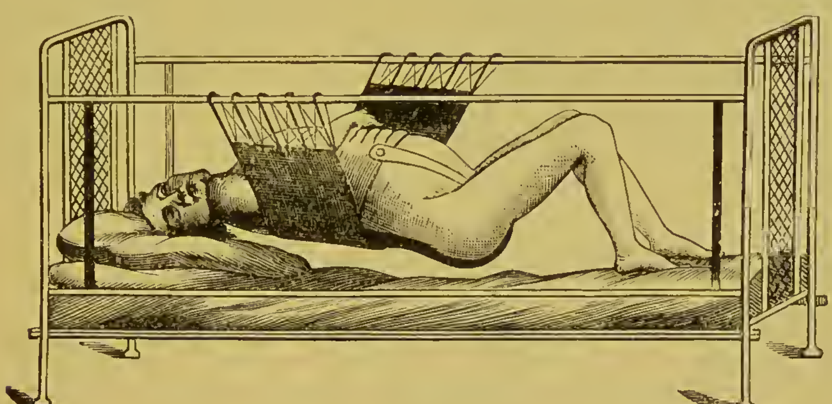


FIG. 406.—Rauchfuss's sling for tubercular spondylitis.

The head of the bed is raised, so that counter-extension may be secured by the weight of the body. The weight used depends upon the age of the patient. Three or four pounds is usually sufficient in treating children, and from six to eight pounds suffices for adults. Rauchfuss's sling is of great service, particularly in case the middle part of the vertebral column is diseased (Fig. 406). It can be adjusted easily to almost any child's bed, and by giving the child this posture sufficient unburdening or extension of the vertebral column is attained. In order that bedsores may not develop at the site of the gibbosity, one can cut a corresponding hole in the sling, and shoulder straps and perineal straps can be arranged for the purpose of holding the child more securely. One can also, after König, fasten the children to the sling by means of a close-fitting jacket with sleeves and thigh pieces. Much the same result as that secured by Rauchfuss's sling is accom-

plished by placing the patient upon a roller cushion firmly stuffed with hair, or a firm wood-wool or chaff cushion which is not too broad. For very little children the standing beds, after Phelps (Fig. 407), are very serviceable. The wooden box-splint has a place cut out for the arms, the anus, and the heels. It is well padded with a jute cushion and waterproof material. The head of the child is fixed in extension, the trunk is fastened by a bodice of leather, and the extremities are enveloped in a flannel bandage. The child should have his bed changed every week, and his legs should be freshly bandaged every day, for the sake of securing active and passive movements of the joints. Beds of plaster of Paris are also very serviceable, especially for little children. They have been particularly recommended by Lorenz. With the child lying on its stomach, its back and head are covered with cotton and a piece of linen, and over these plaster bandages are applied (together with thin board), both longitudinally and transversely. After hardening has taken place the edges are trimmed, covered with gauze compresses soaked in plaster, and then smoothed over.

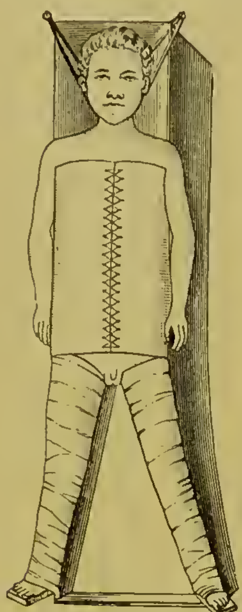


Fig. 407.—Phelps's standing bed for tubercular spondylitis in small children.

In order that the children may be able to go about, a great many forms of portable apparatus have been recommended. That of Taylor (Fig. 408) is best known, in which the bend in the vertebral column is straightened by two plates. It is suited only for beginning kyphosis. The fixation and ex-

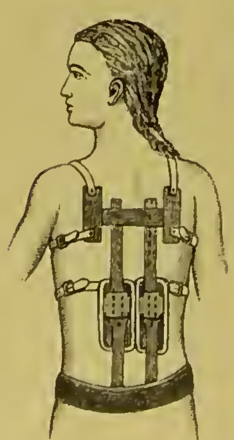


Fig. 408.—Taylor's spring apparatus for beginning kyphosis.

Fig. 409.—Glisson's extension apparatus for fixation of the cervical vertebræ.

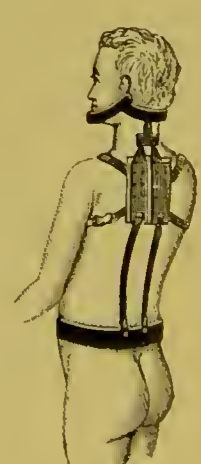


Fig. 410.—Taylor's apparatus for fixation of the cervical vertebræ.

tension of the cervical segment of the vertebral column by means of a portable apparatus can be accomplished by the use of Glisson's apparatus as represented in Fig. 409, or Taylor's extension apparatus as shown in Fig. 410. All these forms of supporting apparatus have been rapidly superseded of late by the plaster-of-Paris and felt jackets, and we are greatly indebted to Sayre in particular for the general introduction of the latter into surgical practice. As has been shown, especially by Esmarch, Madelung, Nebel, and others, the action of these plaster-of-Paris and felt jackets, particularly when they are provided with a mechanism for producing extension, is very beneficial in cases of kyphosis.

Their preparation for use in case of kyphosis is, generally speaking, the same as given above (page 807) in connection with the treatment of scoliosis. The following brief statement is all that need be added here:

In kyphosis there should be only a moderate suspension, or, at all events, the attempt should not be made to overcome the existing deformity. One

a *b* *c*

Fig. 411.—Apparatus for fixation and extension of the cervical vertebræ in spondylitis of the cervical and dorsal segments: *a*, Sayre's jury mast; *b* and *c*, Nebel's jury mast.

may here also, as in treating scoliosis, apply the jacket, after Peterson and others, while the patient is in a horizontal position, by placing the head and the pelvis with the lower extremities on separate tables and supporting the gibbosity by means of a strap from above. The latter is also included in the plaster of Paris. To protect the gibbosity from pressure, plates of felt or boletus igniarius are sewed to the inner surface of the woollen shirt, or, better still, a piece is cut out of the jacket behind. The jacket should reach in front somewhat above the nipples, and should cover the lower half of the scapula behind. After the plaster-of-Paris jacket hardens the patient is placed in as horizontal a position as possible. The jacket is usually not arranged so as to be taken off, as in scoliosis, but it remains in place several weeks if no special reason exists for its removal. In suitable cases it may be left on for several months. In milder cases the jacket is usually made so that it can be taken off, as in scoliosis.

The simple plaster-of-Paris jacket can be modified in the greatest variety of ways. For the support of the jacket, shoemaker's thin board or splints of iron may be included in the plaster of Paris. In order to secure extension at the diseased part of the vertebral column, in dorsal kyphosis, for instance, plaster-of-Paris bandages have been applied both above and below the gibbosity, with handles included in the plaster, to which extension screws are fastened (Wyeth, Stillman). For the fixation and extension of the cervical segment of the vertebral column in cervical and dorsal spondylitis, the jury-mast jacket is frequently used—that is, Sayre's jury-mast (Fig. 411, *a*). A two-pronged fork with three flexible hoops of iron about the thorax is included in the plaster of Paris that forms the jacket (Fig. 411, *c*). The fixation and extension of the head is accomplished by means of a Glisson's collar or an analogous apparatus (Fig. 411, *a* and *c*). One can also construct a jury-mast of flexible iron hoop in a simpler way, after Nebel (see Fig. 411, *b*). Beger recommended that in cervical spondylitis the head and the thorax should be inclosed by separate plaster-of-Paris bandages, and that the two bandages should then be united by two iron bands included in the plaster of Paris (Fig. 412). This interrupted plaster-of-Paris bandage is applied with the patient in a slightly suspended posture sitting upon a table.

FIG. 412.—Fixation of the cervical vertebræ in spondylitis of the same by means of an interrupted splint (Beger).

As in scoliosis, so in treating kyphosis also, water-glass jackets have been used. Flannel bandages are used for the first layer. The first water-glass bandages must not be too much saturated. To fix the jacket in its place three or four plaster-of-Paris bandages are applied, which are removed again after two or three days. The dressing may be strengthened by the use of shoemaker's thin board or flexible iron splints. Schönborn and Falkson applied in the treatment of cervical and dorsal spondylitis a water-glass jacket which surrounded the head, the neck, and the trunk, prepared over a plaster-of-Paris model taken beforehand. It can be laced, and is lined with flannel. The plaster of Paris is applied about the head, the neck, and the chest, reaching below the nipples (see the dotted line in Fig. 413), while the patient is slightly suspended and sits upon a table. The head is shaved beforehand, and extension is secured by means of a loop of adhesive plaster about the chin and the occiput (Fig. 414). After the plaster-of-Paris jacket becomes hard it is cut open, taken off, and joined together again with plaster-of-Paris bandages, which also bridge over the gaps for the face and the arms. It is

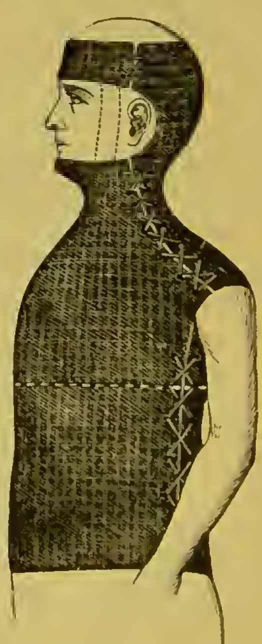


FIG. 413.—Removable water-glass jacket for spondylitis of the cervical and dorsal vertebræ (Schönborn and Falkson).

then filled with plaster of Paris. After from six to twelve hours the plaster-of-Paris bandages are removed and the water-glass jacket is formed over the plaster-of-Paris cast, as represented in Fig. 413.

Felt jackets are applied in essentially the same manner as described for scoliosis (page 812). They are likewise arranged for lacing, and, if necessary, are provided with one or with a double jury-mast—after Beely, for example (Fig. 415)—for fixing the head. Madelung, Vogt, Beely, and others have found the felt jacket particularly useful in kyphosis.

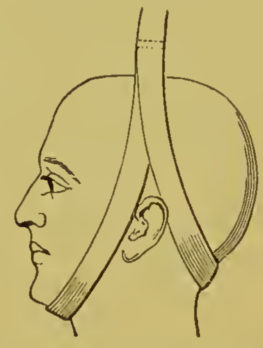


Fig. 414.—Falkson's sling of adhesive plaster for extension of the spine.

Heusner makes use of a sort of supporting bodice in treating caries of the vertebræ, which is prepared from soft felt with starch bandages wound about it three or four layers deep. Between the turns of the bandage plates of pliant reed-work are inserted, and pieces of firm India-rubber tubing are laid along the crests of the ilium, on both sides, between the felt and the reed-work, which are pressed firmly into the soft parts in applying the bandages. By means of this wall above the crests of the ilium the jacket is prevented from slipping down. Shoulder supports or, if necessary—in case of lordosis, for instance—steel supports with springs are included in the dressing as supports for the arms. The head is supported by an iron rod with a crosspiece at the nape of the neck.

Fig. 415.—Felt jacket with double jury-mast for fixation of the head in spondylitis of the cervical vertebræ.

Any abscesses or exposed carious places that may exist do not in the least contraindicate the application of the jacket. In such cases one uses jackets with openings in them, or lays them over the antiseptic protective dressing and arranges them so that they can be taken off.

The further treatment of tubercular spondylitis or kyphosis is essentially of a symptomatic character. We have already emphasized the fact that general treatment, such as giving good food, care for pure air, salt baths, etc., is of great importance in every stage of spondylitis. Any abscesses that may form are no longer, as formerly, a *noli me tangere*, but they are incised under antiseptic precautions, scraped out, and drained. Large abscesses which are to be treated with the patient moving about may be evacuated by a trocar, knife, or aspirating syringe, and then thoroughly irrigated with 1-to-1,000 or 1-to-5,000 bichloride of mercury, and an emulsion of iodoform and glycerin (10 to 90, or ten parts iodoform, fifty parts water, and fifty parts glycerin). P. Bruns brought about a permanent cure in twenty out of twenty-two cases by puncture and the injection of a mixture of iodoform and glycerin. If necessary, the

injections are to be repeated in from two to three weeks. We have already stated (pages 548, 549) that one must use caution in the incision of retropharyngeal abscesses, lest the children suffocate from the aspiration of pus into the air passages, and we have also described there the way in which such abscesses should be opened. It is best done from the outside. Psoas abscesses which are still located high up above the crest of the pelvis are opened by an incision parallel to the crest of the ilium, with a counter-opening behind over the quadratus lumborum.

I have also of late treated tubercular spondylitis by injection of a ten-per-cent mixture of iodoform and glycerin with good results. I injected into the focus of the disease from two to ten grammes of the mixture, according to the age of the patient, by the use of good-sized sterilized aspirating needles.

Operative treatment of the diseased focus itself has been attempted of late more and more. Boeckel has demonstrated by experiments upon the cadaver and by successfully scraping out the second and third dorsal vertebræ that it is not extremely difficult to reach the body of a vertebra. In case of caries of the bodies of the dorsal vertebræ, one obtains sufficient room, by the resection of a piece of a rib three or four centimetres long in a median direction from the angle, to enable one to reach with the finger the body of the vertebra after pushing aside the pleura. The proximity of the aorta, the inferior vena cava, and the thoracic duct need not be feared in operating upon the living subject, inasmuch as a sinus is usually present through which one can easily pass to the body of the vertebra. The body of a lumbar vertebra is exposed by means of an incision along the outer border of the sacro-lumbalis muscle, as in nephrectomy, and then one passes in behind the colon and in front of the kidney. Here any psoas abscess that may exist is opened, and the diseased vertebra reached through this. Vincent makes a longitudinal incision on both sides of the spine to the outer side of the transverse processes, with a transverse incision perpendicular to these on a level with the gibbosity. He then resects one or more ribs, divides the intercostal muscles, and, after pushing aside the pleura, reaches the diseased vertebra. Chipault recommends for exposing the vertebræ a longitudinal incision over the spinous processes, with resection of the arches with a flat-bladed bone forceps. The above-mentioned injection of a ten-per-cent sterilized mixture of iodoform and glycerin should be combined with the scraping out of the tubercular focus in the vertebræ. One must not place too much hope on a cure from an operation of this sort.

Operative treatment may be resorted to in a similar manner in the case of injuries of the bodies of vertebræ.

In case of primary tuberculosis on the posterior circumference of the vertebræ (processes and arches) one should likewise operate in suitable cases. I have secured a complete and permanent cure by scraping out and resecting the transverse processes and a part of the vertebral arch. Resection of the spinous processes and the arches is especially indicated in case of caries of the vertebræ with paralysis of the spinal cord from compression, and remarkably good results have been thereby secured (Southam and others). After resection of one or more arches and opening the vertebral canal, one should scrape out the tubercular focus in the vertebral body and treat it with iodoform.

This opening of the vertebral canal for spondylitic paralysis should only be attempted in cases of extreme necessity after every other method of treatment has been tried. This has been especially emphasized by Kraske also. Cases of paralysis from compression in which the dura is not yet affected are the most favourable for this operation.

In syphilitic spondylitis or kyphosis the local treatment is essentially the same as that for tubercular spondylitis. An antisyphilitic course of treatment is to be instituted (inunctions, hypodermic injections of mercury, iodide of potassium) (see Principles of Surgery, § 84).

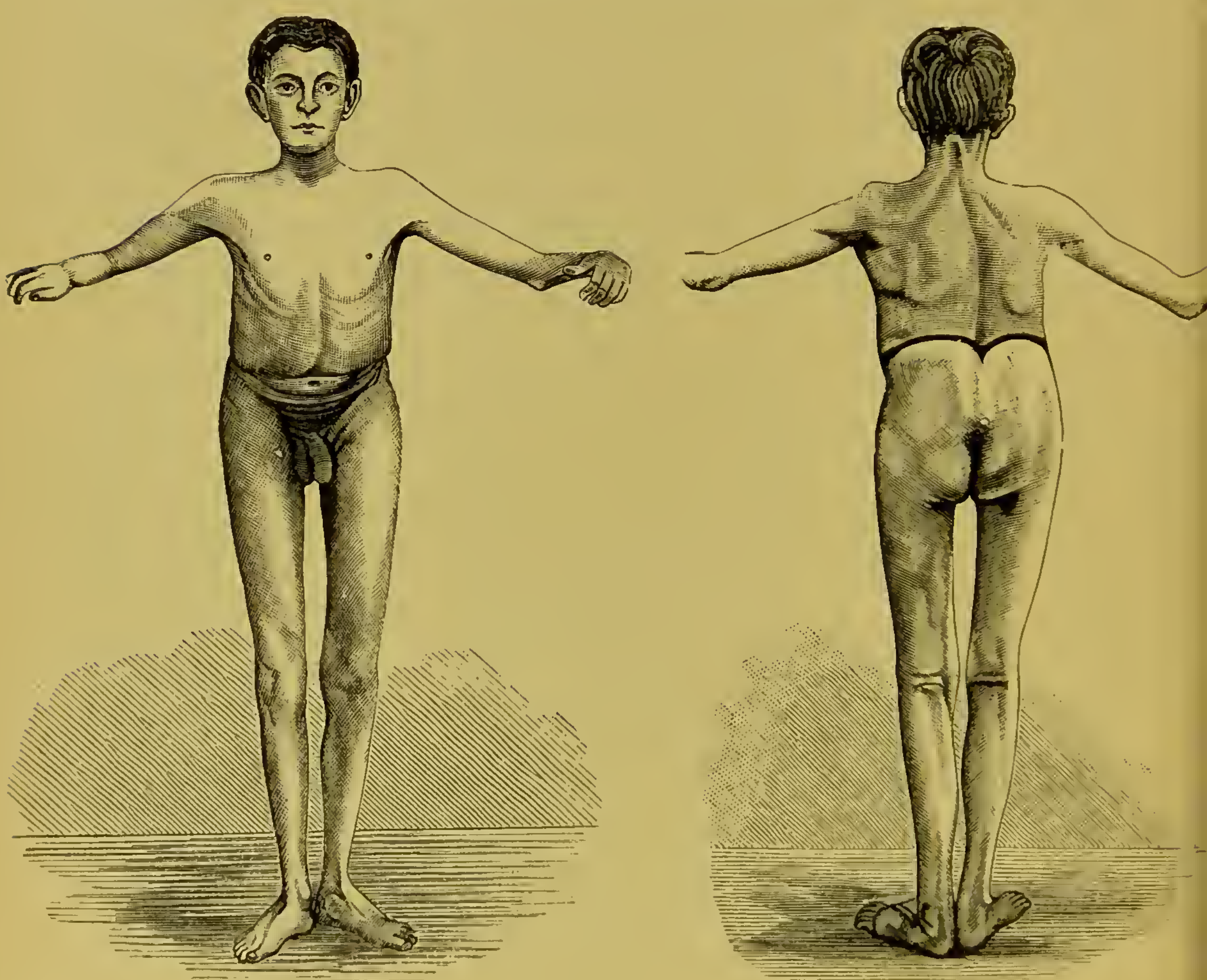
§ 147. **Lordosis.**—By lordosis is understood curvature of the spine with its convexity directed forward (see page 659, Fig. 340, Lordosis of the lumbar segment of the spine, with pectus carinatum). Lordosis is the least common of the curvatures of the spine. It occurs most frequently in the lumbar segment, and may arise from all those pathological changes which lead to a strong inclination of the pelvis. This is true of the compensatory lordoses of the lumbar segment of the spine in connection with congenital dislocation of the hip or contractures of the lower extremities, in consequence of coxitis, for example. One observes lordosis among those who are accustomed to carry heavy loads in front of them, and also among tailors. Lordosis very seldom becomes fixed.

The symptoms of lordosis of the vertebral column—the lumbar segment, for instance—are chiefly an abnormal prominence of the abdomen and the gluteal region, with a corresponding sinking in of the lumbar region (see Fig. 416).

Extreme lordosis may also arise from spondylolisthesis of the last lumbar vertebra—that is, when it, with the overlying segment of the vertebral column, slides forward and downward over the base of the sacrum. The body of the last lumbar vertebra may, in consequence of the increasing displacement, descend more and more until it enters the true pelvis, so that its basal surface lies on the ventral side of the sacrum, and one can distinctly feel the bony prominence *per rectum.*

Injuries and inflammation, and especially deformity of the fifth lumbar vertebra caused by pressure, with sagittal lengthening of its body, are the chief causes of spondylolisthesis. It is also observed occasionally in the course of tabes (see page 829.)

The etiology of spondylolisthesis has received various explanations. The displacement of the fifth lumbar vertebra *in toto* has been usually looked upon as the cause. According to Neugebauer, the existence of spondylolisthesis is not conditioned upon a displacement proper of the fifth lumbar vertebra, but chiefly upon a deformity of the same from



a *b*

Fig. 416.—Extreme lordosis produced by a sliding forward of the lumbar segment over the base of the sacrum (spondylolisthesis) after fracture (Volkmann's clinic).

pressure, owing to certain predisposing conditions, with which a displacement of the body of the vertebra is associated. The condition of the interarticular portions of the arch of the fifth lumbar vertebra furnishes, according to Neugebauer, the key to an understanding of

the anomaly. The arch, and consequently the entire fifth lumbar vertebra, are lengthened in their sagittal diameter in consequence of a break in the continuity of the interarticular portion of the arch, after injuries, for example, or because the anterior and posterior centres of ossification have not coalesced (congenital spondylolysis)—that is, we have to do either with a congenital or traumatic break in the continuity (spondylolysis) of the arch of the fifth lumbar vertebra. In order that out of this spondylolysis a spondylolisthesis should arise, however, there is need, according to Neugebauer, of still other factors, as given especially in pregnancy. Hence the frequent occurrence of the anomaly among women. Where traumatic and congenital change in the interarticular portion of the arch of the fifth lumbar vertebra are wanting, Neugebauer believes that the deformity may be conditioned upon a transverse fracture of the superior articular processes of the sacrum. According to Strasser, spondylolisthesis also arises from primary arthritis deformans, which Neugebauer considers to be secondary in nature. Spondylolisthesis is to be considered, accordingly, as a deformity due to the weight of the body. If the above-mentioned pathological changes once exist, then, at the beginning of the anomaly, the body of the fifth lumbar vertebra projects beyond the anterior border of the sacrum, and as it finds less and less support here as its sagittal axis lengthens, it must finally, in consequence of the superimposed weight, become more and more displaced forward and downward, and the entire vertebral column lying above the fifth lumbar vertebra naturally follows this displacement of the lowest lumbar vertebra.

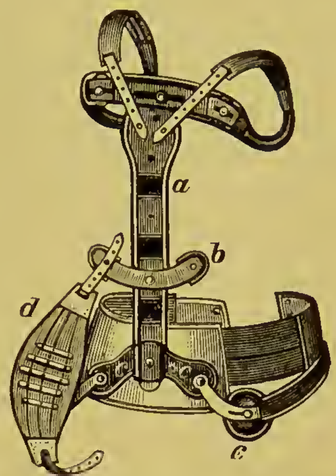


FIG. 417.—Nyrop's brace for lordosis.

Leser has described a case of traumatic spondylolisthesis with extreme lordosis of the vertebral column seen in Volkmann's clinic (Fig. 416).

The treatment of lordosis of the vertebral column is directed chiefly against its cause. In all diseases by which the pelvic inclination is changed—such as, for example, diseases of the hip joint—an effort should be made to prevent too great a contracture or too much pelvic inclination. In fully developed cases gymnastic exercises, and above all supporting apparatus, such as plaster-of-Paris and felt jackets, are to be applied for correcting the deformity. Among the different forms of supporting apparatus that can be worn, Schreiber especially rec-

ommends that of Nyrop (Fig. 417). It consists of a steel support for the back (*a*), with a crossbar above, shoulder crutches, and a pelvic belt. Above the latter is a transverse plate (*b*) on the steel support, with an elastic body belt (*d*). To the pelvic belt are attached two broad pads (*c*) for the gluteal region.

§ 148. **Spondylitis Deformans** is characterized anatomically by a defibrillation of the intervertebral disks and by proliferation of cartilage and bone, especially on the anterior and the lateral aspects of the vertebral column. The proliferations of bone give rise to firm synostoses between the single vertebræ, which are sometimes extensive. One occasionally observes the same processes in the articulations of the vertebral processes, especially, for example, on the cervical vertebræ. Associated with the defibrillation of the cartilage and the periosteal proliferations on the anterior and lateral aspects of the bodies of the vertebræ and the intervertebral foramina we often find an increasing atrophy and bending of the vertebræ, so that there arises a corresponding curvature of the spine, most frequently an abnormal flexion of the same.

The etiology of spondylitis deformans, like that of arthritis deformans, is as yet obscure. It usually begins spontaneously, partly in connection with injuries, and also after infectious inflammations of the joints—e. g., after gonorrhœal and polyarticular rheumatism. The age is of great importance, and spondylitis deformans is, like arthritis deformans, essentially a senile disease, which breaks out sometimes spontaneously and sometimes in connection with a determining cause (injury, infection).

The course of the disease is very chronic, and it usually occurs among older people. As a rule, there is a variable amount of pain of a rheumatic character, and there are often crackling and grating sounds, caused by movements of the vertebral column. There finally ensues a diminished mobility of the vertebral column, at first of the cervical segment, and this is accompanied by neuralgia, atrophy of the muscles, and pronounced paralysis in the distribution of the spinal nerves, which are compressed by the abnormal growth of bone. The typical outcome is synostosis of the diseased vertebræ, which is especially disturbing when it occurs upon the upper two cervical vertebræ. The bony proliferations can only rarely be felt externally, because their location is deep down in front or to one side. They can sometimes, however, be distinctly felt from within the pharynx or on the sides of the cervical vertebræ.

The treatment of spondylitis deformans is attended with but little success. Gymnastic exercises and massage are especially to be recom-

mended, warm baths also, the use of thermal springs (Wildbad, Gastein, Pfäfers), residence in southern localities, etc. Iodide of potassium and preparations of iron given internally, and nourishing food are helpful.

In the course of tabes, osteoporosis and softening of the vertebræ sometimes result, so that fractures, almost exclusively those of the lumbar vertebræ, may result from slight injuries (Pitres, Vaillard, König). Disease of the vertebræ in tabes runs a clinical course similar to that of spondylolisthesis described on page 825.

§ 149. **Tumours of the Spine and the Spinal Cord.**—Primary tumours of the vertebral column and the spinal cord are very rare. Myelogenic and periosteal sarcomata and myxomata, as well as exostoses and enchondromata, have been observed on the spine. Metastatic tumours of the spine are more common, carcinomata and sarcomata, which usually appear in multiple form—e. g., in carcinoma of the mamma or the uterus. Destruction of the body of a vertebra gives rise to a corresponding kyphosis of the vertebral column, and pressure upon the spinal cord with paralysis. Tumours involving the bodies of the vertebræ are usually inaccessible for surgical treatment. Only those of the vertebral arches and their processes can ordinarily be operated upon. Regarding congenital sacral tumours in the region of the sacrum and the coccyx, the reader is referred to the surgery of the pelvis.

Tumours of the spinal cord and its meninges have recently been thoroughly described, especially by Gowers and V. Horsley, and Horsley was the first to cure by operation a fibro-myxoma located on the spinal cord.

Horsley has collected from the literature of the subject fifty-eight cases of tumours of the membranes of the spinal cord. The extradural tumours are lipomata, sarcomata, and echinococcus cysts; the intradural are myxomata, fibromata, sarcomata, and psammomata. Neisser has tabulated thirteen and Maguire twenty cases of echinococcus cyst of the vertebral column which were in most cases extradural. It was found twice in the substance of the spinal cord itself. It may be mentioned here that intradural and extradural tuberculosis has also been repeatedly observed. Lipomata of the spinal meninges are rare. Témoin collected five cases in addition to one that came under his own observation. Four of the lipomata were situated within the vertebral canal, and two partly within and partly without. The latter variety may be mistaken for spina bifida.

The symptoms attending intradural tumours are especially constant. The first symptom, according to Horsley, is pain. Then comes later

the motor paralysis, from pressure of the tumour upon the spinal cord; but this precedes the paralysis of sensation. The extension of the symptoms from one half of the body to the other is of special diagnostic worth, and determination of the location of the tumour is made much easier thereby. The pain becomes very intense, according to Horsley, with the appearance of the paralytic symptoms. The order of the symptoms is usually the same in extradural tumours also—that is, pain at first, then motor paralysis, and at last paralysis of sensation. Intradural tumours are usually less malignant than extradural ones, and the symptoms therefore develop more slowly in the former.

Of other symptoms attending extradural and intradural tumours we mention, after Horsley, the following in addition: increased reflexes, spasms, ankle clonus and muscular rigidity (especially in intradural tumours).

The size and reaction of the pupil is changed only when the spinal cord suffers pressure above the level of the second dorsal nerve. The pupil is then smaller than that of the other eye, in consequence of paralysis of the dilator (sympathetic nerve), and is almost without reaction. The pupillary filaments of the sympathetic nerve have, as is well known, a special centre in the spinal cord (cilio-spinal centre), which lies on a level with the lowest cervical and the first dorsal vertebræ (Budge). Paralysis of the bladder, with subsequent cystitis and nephritis, ensues in the further course of the paralysis. Vasomotor disturbances (œdema) are less frequent, occurring but six times in the fifty-eight cases. Bedsores, cystitis, etc., usually appear at the end. The patients die mostly from marasmus, pyæmia, or uræmia, in consequence of nephritis.

The size of the tumours is usually small, corresponding to the diameter of the vertebral canal. We have most frequently to do with tumours of the connective-tissue type which originate in the arachnoid, less frequently in the pia mater. The influence upon the medulla is very variable. Softening of the spinal cord follows more frequently from intradural than from extradural tumours.

The diagnosis of tumours of the vertebral canal is difficult in the earlier stage so long as pain is the only symptom present. The constancy and the location of the pain are of importance, and also the appearance of pressure symptoms, of motor paralysis, and paralysis of sensation, as has been mentioned above.

The treatment of tumours of the vertebral canal or the membranes of the spinal cord, with symptoms of pressure upon the spinal cord, consists in removing the tumour after opening the vertebral canal by resection of the vertebral arches (laminectomy). The operation of

laminectomy was suggested by Heister, and has been performed a great many times for injuries of the vertebral column, especially badly united fractures with paralysis from compression of the spinal cord and for the removal of tumours of the membranes of the cord.

§ 150. **Resection of the Vertebral Arches (Laminectomy).**—Laminectomy is indicated in connection with various diseases and injuries of the vertebral column and the spinal cord ; in fractures and dislocations with compression of the spinal cord, for the extraction of splinters of bone or foreign bodies from the vertebral canal or the spinal cord, for tumours, etc. W. Thorburn has recently summarized the surgery of the spinal cord in an excellent monograph based upon the reports now in our possession (London : Griffin & Co., 1889), and has shown that modern surgery in this field also is securing better and better results.

Laminectomy is performed, with strict attention to asepsis, somewhat as follows : The incision through the skin is made directly over the spinous processes and of the desired length. Horsley then removes the spinous process of the vertebral arch that is to be resected at its base with a powerful bone-cutting forceps. Through the longitudinal incision the periosteum and the muscles are displaced to both sides by means of a periosteal elevator. The arch is then divided with the chisel near the transverse process. Horsley uses a trephine whose crown has about the diameter of the vertebral canal, or he saws partly through the bone, and completes the division with a bone-cutting forceps The removal of the bone must be accomplished with great care. After one or more arches have been resected, the dura mater appears, covered by a very vascular adipose tissue and loose connective tissue. To control the hæmorrhage as far as possible, one should divide this adipose and connective tissue exactly in the median line. If necessary, after the adipose tissue has been retracted to both sides with blunt hooks, the dura, which now lies exposed, is seized with small forceps and divided exactly in the median line by a longitudinal incision of proper length. Since reflex movements easily ensue from mechanical irritation of the dura and the posterior columns, this part of the operation must be performed while the patient is fully under the influence of the anæsthetic ; otherwise a reflex movement might have very unfortunate results. The cerebro-spinal fluid, which now flows abundantly, is removed with aseptic pledgets. One can then carefully examine the dura and the spinal cord as to appearance, consistence, etc. If one suspects an abnormality of any kind upon the anterior surface of the spinal cord—e. g., a new growth, a splinter of bone, or a ball—an aneurism needle is carefully passed around the spinal cord. In the case treated by Horsley he did not suture the

wound in the dura after the completion of the operation, but left it open. The external wound is drained, closed by suture, and covered with a large antiseptic protective dressing. Wright succeeded in uniting afterward the resected vertebral arch. Pain in consequence of possible adhesion of the dura mater and the posterior nerve roots with the bottom of the wound did not appear in Horsley's case, for instance. The patient was completely and permanently freed by the operation from his tumour and the intense pain that was associated with it. More recently tumours of the spinal canal have been removed in a large number of instances by laminectomy. In some cases the operation was successful, while in others it proved fatal (Bozzolo and others). Shaw and Bush removed with success a large organized thrombus of the spinal canal that was pressing on the cauda equina; it had developed as the result of a traumatism occurring a year before.

Puncture of the Subarachnoid Space in the Lumbar Region (after Quincke).—Quincke was the first to recommend and successfully perform lumbar puncture to bring about diminution of pressure in the cerebral ventricles, or in the subarachnoid spaces of the brain and the spinal cord. As is well known, the subarachnoid spaces of the brain and the spinal cord communicate with one another and with the cerebral ventricles, so that by lumbar puncture the acute and chronic compression of the brain from excess of cerebro-spinal fluid can really be diminished. This procedure is useless in cases where, from partial sclerosis of the subarachnoid space, or from closure or compression of the aqueduct of Sylvius, the communication that has been mentioned does not exist. Lumbar puncture is most frequently indicated in children with acute and chronic hydrocephalus or with tubercular meningitis, and also at every age in connection with all diseases of the brain and the spinal cord which are attended with increased compression of the brain. The operation has also a prominent diagnostic significance. It informs us, for example, as to the nature of the existing exudation, whether an increase in the cerebro-spinal pressure really exists or not, etc.

Lumbar puncture is performed between the third and fourth or between the fourth and fifth lumbar vertebræ. Injury to the spinal cord by the point of the needle is impossible, as it reaches in adults only to the second and in children in their first year only to the third lumbar vertebra. If puncture is properly performed, injury to the nerve roots of the cauda equina floating in the cerebro-spinal fluid is just as little to be feared, as they elude the needle.

The technique of lumbar puncture as practised by Quincke is as follows: The patient lies upon the left side, with the lumbar segment

of the spine sharply bent forward. If there is marked stupor, especially in the case of a child, the use of an anæsthetic is unnecessary. The puncture is made with a fine hollow needle below the arch of the third or fourth lumbar vertebra. In young children one can make the puncture about midway between two spinous processes of the lumbar vertebræ above mentioned, but, on account of the strong intervening ligament, it is better to insert the needle a few millimetres to one side of the median line, and it should be directed a little upward, and in such a way as to strike the median line on the posterior surface of the dura. In children the needle is inserted to the depth of about two centimetres, and in adults to the depth of from four to six centimetres. The escape of cerebro-spinal fluid shows that one has reached the subarachnoid space. The amount of cerebro-spinal fluid to be evacuated varies according to the nature of the case. In adults, for example, it is anywhere from twenty to one hundred cubic centimetres, and in children from two to seventy cubic centimetres. The operation may be repeated several times at certain intervals, as necessity requires.

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